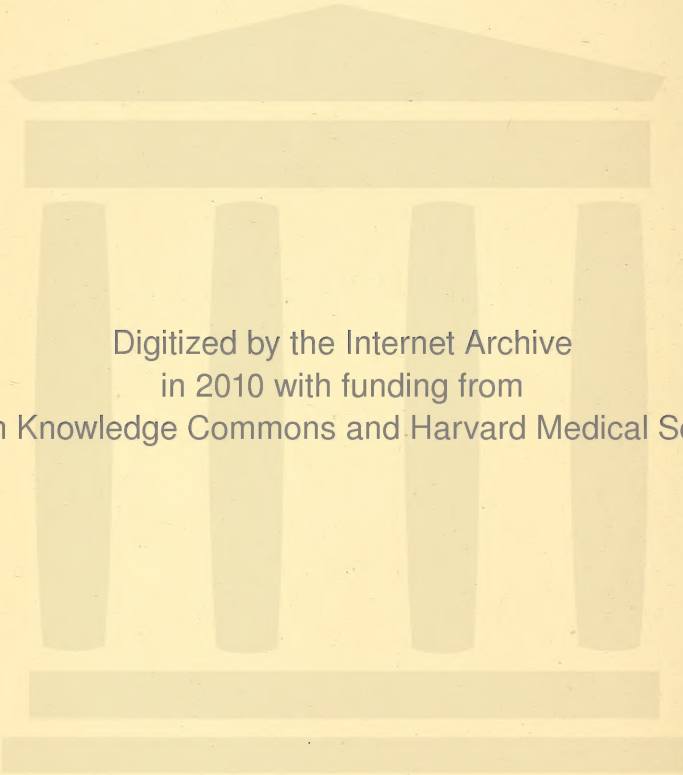
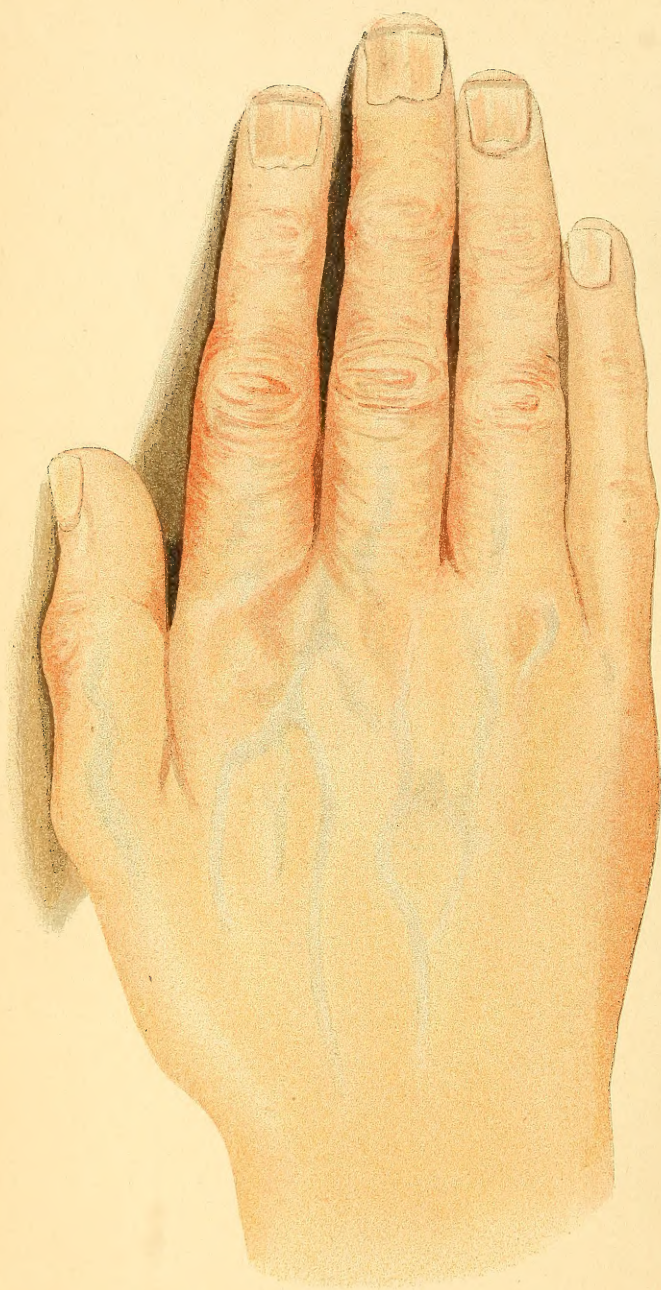


Charles L. Sudder.

INJURIES AND DISEASES
OF
NERVES



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PLATES 1 AND 2.

Showing the difference between the two hands of the same patient nine months after section of the median nerve at the wrist. The left hand shows the glossy, shiny, and tightly stretched skin and the curved fibrous nails which are characteristic of nerve injury.

Frontispiece.



INJURIES AND DISEASES

OF

NERVES

AND THEIR SURGICAL TREATMENT.

BY



ANTHONY A. BOWLBY, F.R.C.S.

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HOSPITAL; SURGEON TO THE ALEXANDRA HOSPITAL FOR HIP DISEASE.



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TO
THE SURGICAL STAFF OF ST. BARTHOLOMEW'S HOSPITAL

This Volume is Dedicated

IN GRATITUDE FOR THEIR INSTRUCTION WHILST A STUDENT,
FOR THEIR CONSTANT ASSISTANCE IN LATER YEARS,
AND FOR MANY ACTS OF KINDNESS AND CONSIDERATION EXPERIENCED
BY THE AUTHOR WHILST ACTING AS SURGICAL REGISTRAR
IN THE WARDS OF
ST. BARTHOLOMEW'S HOSPITAL

P R E F A C E.

IT is now about nine years since, when House Surgeon at St. Bartholomew's Hospital, I first had the opportunity of treating some patients with wounded nerves. The cases interested me, for I found that but little was at that time known of the prognosis or clinical course of injuries of nerves. The treatment by suture was then in its infancy, and the results obtained by this method had not been ascertained.

I therefore determined to try and obtain for myself the answers to problems which were not yet solved, and, as a result, the present work has gradually developed. In it are included the Jacksonian Prize Essay of the Royal College of Surgeons for the year 1882, and the Astley Cooper Prize Essay for the year 1886. The book may indeed be said to be merely a condensation of the latter essay, with the addition of such further knowledge as I have gained during the last three years. A portion of the following pages has also appeared in the *Lancet* for 1887, in the form of Lectures delivered at the Royal College of Surgeons in that year.

The work throughout has been done entirely from a clinical aspect, and whatever value it may possess is due to the fact that large numbers of patients suffering from nerve injuries of the most various kinds have been kept under constant observation for many years.

I do not think that the practice of any one surgeon could have afforded a sufficient field for observation, but, fortunately for my purposes, I have been attached to a large hospital into which many and various accidents are yearly admitted, and in which my opportunities for clinical study have been practically inexhaustible.

To the Surgical Staff of St. Bartholomew's Hospital, I indeed owe a debt of gratitude larger than I can ever expect to pay, for, without their constant aid and encouragement, without access to

the patients under their care, I could never have profitably studied the clinical aspect of my subject.

I have, however, not only described the cases observed by myself, but have endeavoured as far as possible to give due weight to the opinions and writings of others. This, indeed, was very necessary in dealing with some of the more rare affections in which my own experience was but scanty and insufficient, and I have therefore supplemented it by quoting cases derived from various sources. But, although I am indebted to many writers, it is to the works of Dr. Weir Mitchell that my acknowledgments of assistance are especially due. I have found his book on "Injuries of Nerves," published in 1872, so full of accurate observation and so complete in its realistic descriptions, that after the lapse of seventeen years there is but little of value to add to those parts of the subject he has made so peculiarly his own.

In other respects, however, our knowledge of the pathology, clinical aspects and treatment of injuries of the nerves has made considerable advances, and although in some directions there is yet room for much further work, I have thought that an account of cases observed by myself, and an attempt to summarize our knowledge of this branch of surgery, might be of interest to members of the medical profession.

I am well aware that with further experience than I have yet had the book might become much more perfect than it is; but inasmuch as most of the work is already as complete as I can hope to make it, I have thought it best to delay no longer.

The illustrations are from drawings by the late Mr. T. Godart, and the blocks for printing have been prepared by the Illustrated Medical News Company.

My best thanks are due to my friend and colleague, Mr. D'Arcy Power, for much valuable advice, and for his assistance in correcting the proof-sheets.

ANTHONY A. BOWLBY.

CONTENTS.



CHAP.	PAGE
I. ANATOMY OF THE NERVES	I
II. PHYSIOLOGY OF THE NERVES	8
III. CHANGES IN NERVES AFTER SECTION, THEIR DEGENERATION AND REPAIR	16
IV. UNION BY FIRST INTENTION	30
V. TROPHIC CHANGES CAUSED BY NERVE INJURY	41
VI. SYMPTOMS OF NERVE INJURIES	62
VII. INJURIES OF SPECIAL NERVES	84
VIII. TREATMENT OF CASES OF NERVE SECTION	123
IX. THE VALUE OF PRIMARY SUTURE OF NERVES	152
X. SECONDARY SUTURE	164
XI. THE VALUE OF SECONDARY SUTURE OF NERVES	197
XII. VARIETIES OF NERVE INJURIES	211
XIII. VARIETIES OF NERVE INJURIES—(<i>continued</i>)	231
XIV. VARIETIES OF NERVE INJURIES—(<i>continued</i>)	243
XV. INJURIES OF NERVES COMPLICATING DISLOCATIONS	263
XVI. COMPLICATIONS OF NERVE INJURIES	270
XVII. REFLEX PARALYSIS	289
XVIII. UNUSUAL COMPLICATIONS OF NERVE-INJURIES: EPILEPSY, CHOREA, AND TETANUS	302
XIX. GENERAL TREATMENT OF THE VARIOUS MORBID CONDITIONS WHICH ACCOMPANY INJURIES OF NERVES	315

CHAP.	PAGE
XX. NEUROTOMY AND NEURECTOMY	322
XXI. NERVE-STRETCHING	332
XXII. THE CLINICAL APPLICATION OF THE OPERATION OF NERVE- STRETCHING	357
XXIII. NEURALGIA AND ITS SURGICAL TREATMENT	392
XXIV. SURGICAL TREATMENT OF EPILEPTIFORM NEURALGIA	419
XXV. NON-TRAUMATIC NEURITIS	442
XXVI. MULTIPLE NEURITIS	467
XXVII. NEUROMA	486

LIST OF ILLUSTRATIONS.



PLATE	PAGE
I, II. TROPHIC CHANGES AFTER NERVE INJURY . . . <i>Frontispiece.</i>	
III. HAND SHOWING TROPHIC LESIONS	53
IV. HAND FROM A CASE OF MULTIPLE NEURITIS, SHOWING ECZEMATOUS ERUPTION	482
FIG.	
I, 2. TRANSVERSE SECTIONS OF NORMAL NERVES	3
3. LONGITUDINAL SECTION OF A DEGENERATE NERVE	17
4, 5. TRANSVERSE SECTION OF A DEGENERATE NERVE	19
6, 7. SECTIONS THROUGH A BULB	20
8. REGENERATION OF NERVE	24
9. REGENERATION OF NERVE	26
10. REGENERATION OF NERVE	28
11. SECTION OF A BULB	28
12. HAND SHOWING ULCERATION OF FINGER-TIP AFTER INJURY . .	44
13. A HAND SHOWING TROPHIC CHANGES IN THE NAILS	47
14. A HAND SHOWING TROPHIC CHANGES IN THE NAILS	48
15. A HAND SHOWING THE DEFORMITY, AND THE AREA OF ANÆSTHESIA AFTER SECTION OF THE ULNAR NERVE (PALMAR SURFACE) . .	85
16. DORSAL SURFACE OF THE SAME	86

FIG.	PAGE
17. PALMAR VIEW OF A HAND AFTER SECTION OF THE MEDIAN NERVE	91
18. DORSAL SURFACE OF THE SAME	92
19. HAND AFTER SECTION OF THE MEDIAN AND ULNAR NERVES .	132
20. CYST ON THE ULNAR NERVE	492



INJURIES AND DISEASES OF NERVES.

CHAPTER I.

ANATOMY OF THE NERVES.

BEFORE studying the nerves in the various abnormal conditions which result from injury, it will be well to take a very brief glance at the nervous system as it presents itself in the healthy body.

Our nervous system is divided into two sub-systems—the “cerebro-spinal” and the “sympathetic.” The first of these is again subdivided into the “central” and “peripheral.” With the former we are not at present intimately concerned, including as it does the brain and spinal cord, which have a pathology of their own, separable in great part from that of the peripheral system, and yet not so widely separated but that the diseases and injuries of the one act and react upon the structure and functions of the other.

It is unnecessary in this place to interpose any account of the minute structure and the physiology of the brain and spinal cord; they will accordingly only be referred to when in relation either to the morbid processes occurring in the nerve-trunks, or else to their anatomy and physiology.

The development of the cerebro-spinal system has been much in dispute; but the most recent investigations have thrown considerable light on the subject, a light which is not without its value in pathology.

The origin of the spinal cord and brain from epiblast has long been conceded, though at first some doubt was thrown on the development of the white matter of the cord. But while the epiblastic origin of

the cord was granted, it was universally believed that the peripheral nerves were formed in mesoblast, a conclusion which was arrived at chiefly owing to the investigations of Remak; and it was not till His challenged the universally accepted doctrine that any real doubt was thrown upon it. Subsequently, Balfour* showed that the whole of the spinal nerves were formed by outgrowths from the cord, a view which has since been supported by other writers.

Löwe, however, while conceding the epiblastic origin of the nerve-tubes themselves, doubted whether the nuclei of the sheath of Schwann are derived from the same source, or from the surrounding mesoblast. On this subject Balfour's opinion was very clear; and I am much more inclined to believe with him, that these nuclei, which play so important a part in nerve regeneration, are originally derived from the same source as the nerve-tubules, which, as we shall presently see, they are capable of forming. The cranial nerves appear to hold the same relation to the encephalon as do the spinal nerves to the cord.

The spinal nerves thus developed spring from the cord by two roots, which when first formed are entirely separate, but subsequently coalesce, and in the fully formed foetus are found united immediately outside their exit from the spinal canal; the fibres of the one mingle with those of the other, and are not separable throughout their peripheral distribution. On the posterior root, immediately before its junction with the anterior, is situated a ganglionic enlargement, consisting of cells and fibres, of which there will be more to say on a future occasion.

In many parts of the body, the nerve-trunks give and receive branches reciprocally, forming what is known in descriptive anatomy as a "plexus," and it is in this manner that the nerves supplying the extremities are composed of fibres which take their origin from different areas of the spinal medulla. In their course through the leg and arm, the general tendency is for the nerve-trunks to accompany the larger blood-vessels, and thus to share with them such protection as their somewhat sheltered position affords.

The nerve-trunks thus constituted are enclosed by a sheath of connective tissue, to which the name of "epineurium" has been given, composed of bundles of fibrous tissue crossing and re-crossing each other so as to form a sort of plexus, in the meshes of which are contained connective-tissue corpuscles, and in which the vessels of the nerve-trunk divide into their smaller branches. A

* In a paper in the *Philosophical Transactions*, vol. clxvi., 1876.

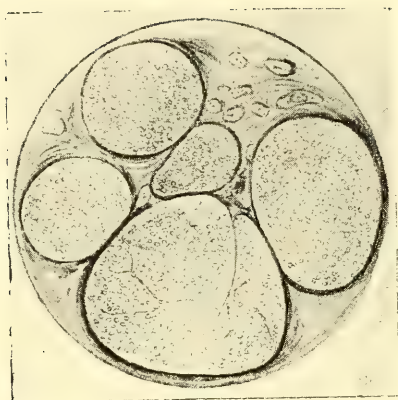


Fig. 1.



Fig. 2.

FIG. 1.

Transverse section of a normal human nerve under a low power.
(Crouch, $\frac{1}{2}$ in.)

FIG. 2.

The same under a higher power. (Crouch, $\frac{1}{6}$ in.)

Page 3.

greater or less amount of fat and lymphatic vessels may also be found in this sheath. Prolongations from the epineural framework pass into the nerve trunk and divide it into fasciculi, each of which is surrounded by a special sheath, the "perineurium," composed also of layers of connective tissue with contained corpuscles and lymph spaces. Within each fasciculus, the nerve-fibres are separated from each other by the "endoneurium," which consists of a homogeneous substance with a few connective-tissue fibres and flattened cells. Small blood-vessels penetrate as far as this sheath, but not into the nerve-fibres themselves.

The intimate structure of the latter consists of, first, the axis cylinder, occupying the centre of the fibre, composed of a soft pale material, capable of being split up into numerous minute fibrils (Max Schultze). Immediately around the axis cylinder is a narrow space containing a fluid albuminous substance, the "peri-axial space" (Klebs). Outside this is the myeline or "medullary sheath," consisting of a thick, fatty, semi-fluid substance, which readily stains black with osmic acid, and is held in a fine honey-comb reticulum. This myeline, under some conditions, is capable of being broken up into sections which have been described by Lantermann and McCarthy. The outermost envelope of the nerve-fibre is the sheath of Schwann, an elastic, hyaline membrane, constricted at regular intervals, the constrictions being known as "Ranvier's nodes." Corresponding to each node the medullary sheath is interrupted, and, with the exception of the sheath of Schwann, the axis cylinder is here devoid of covering; that part of the nerve which lies between any two nodes is called an "inter-annular segment." On the inner side of this sheath are found small nuclei, the nerve corpuscles, generally one to each inter-annular segment, but occasionally more.

As the nerve-fibres approach to their terminations they lose their medullary sheath, and thus come to consist of an axis cylinder surrounded by the sheath of Schwann. Still further, this latter also disappears, and the axis cylinder is covered by an elongated nucleated cell plate, rolled around it and corresponding to a nerve corpuscle (Klein). This also finally disappears, and leaves the axis cylinder bare. It may here be mentioned that, in addition to the medullated fibres just described, there exist a number of fibres which are distinguished by the entire absence of the medullary sheath, and are known as "non-medullated fibres," or "fibres of Remak."

Afferent or Sensory Nerves.—The exact method in which the nerve-fibre terminates varies according to the structure to which it is distributed. In the skin, the axis cylinder is split up into its elementary fibrils, which, with those from other fibres, form a network in the sub-epithelial tissue, from which fine branches may be traced between the epithelial cells themselves. The hair follicle is specially supplied with nerves which maintain their medullary sheath as far as the outer coat of the hair sac and then break up into elementary fibrils, which can be traced as far as the cells of the outer root-sheath (Jobert). In addition to these modes of peripheral distribution, there are special terminal organs in the skin of various kinds.

1. The Pacinian corpuscles, known also by other names, found widely distributed over the body, but specially numerous in the subcutaneous tissue of the volar side of the hand and foot. Each of these bodies is connected with a medullated nerve-fibre, which with its thick sheath represents the stalk of the corpuscle. The latter consists of a great number of capsules placed in a concentric manner around a clear central mass, each capsule being made up of a hyaline elastic membrane, in which are embedded fine connective tissue-fibres, and lined by a layer of flattened endothelial cells; the thickened sheath of the fibre forming the stalk is continuous with the outer capsules. The medullary sheath and sheath of Schwann accompany the axis cylinder in its passage through the capsules, but cease at its entrance into the central clear mass. This latter consists of a limiting membrane, continued from the stalk, and containing a transparent hyaline matrix, in which the axis cylinder divides into two or more branches, at the termination of which are found small irregular or spherical masses consisting of a network of elementary fibrils. Capillary blood-vessels penetrate between the capsules, but not as a rule into the central clear mass.

2. Smaller bodies of a somewhat similar nature occur in the penis and clitoris, and are known as "end bulbs." They consist of several layers of membranes which are continued from the tissue in which the nerve lies, and into which a medullated fibre passes, losing its medullary sheath at the point of entrance. The distribution of the axis cylinder is similar to that which is found in the Pacinian corpuscles. End bulbs are also met with in the conjunctiva, and differ but slightly from those just described.

3. Besides these endings, medullated nerve-fibres may be traced

into the papillæ, which contain what are known as Meissner's corpuscles, and are found in the skin of the hand, foot, glans penis, and lips. They consist, like the other terminal organs, of a fibrous sheath, in the centre of which the nerve-fibres terminate, but in what manner has not yet been exactly ascertained.

Motor or Efferent Nerves.—In unstriped muscles the nerve-fibres are of the non-medullated kind. They divide into small groups of axis cylinders, which form a plexus around groups of muscle-bundles known as the "ground plexus" (Arnold), and from which smaller branches form the "intermediary plexus" around individual bundles of fibres. The muscle cells themselves are surrounded by a network of primitive fibrils, which are described by some authors as terminating in either the nucleus or nucleolus of the cells.

This description also holds good for the termination of nerves in blood-vessels.

In striped muscle, after having formed interfibrillar plexuses, the medullated nerve-fibres enter the individual muscle-fibre in an oblique or vertical manner, and at the same time lose their medullary sheath, the sheath of Schwann becoming continuous with the sarcolemma. The axis cylinder then divides into several thin fibres, which lie embedded in a granular mass—nerve end-plate or muscle-plate—on the surface of the muscle, but within the sarcolemma, and from which some authors describe the distribution of terminal fibrils to the more intimate parts of the muscle-fibre.

In tendons, nerves terminate in various ways—namely, in a network of primitive fibres, in end bulbs similar to those met with in the conjunctiva, or in plates such as are found in muscle.

Finally, in connection with the anatomy of the nerves, it should be mentioned that at a meeting of the Royal Medical and Chirurgical Society (held on January 22, 1884), Mr. Victor Horsley described what he named "*Nervi Nervorum*"—*i.e.*, small sensory nerves distributed to the nerve-trunks themselves. These appeared to arise occasionally from the primary bundles of nerve-fibres, but also, and perhaps more frequently, from the cutaneous branches. Their direction was first at right angles to the primary bundles, and then parallel, running as single medullated fibres of medium size in the connective tissue of the epineurium, and terminating in "end bulbs" similar to those met with on the conjunctiva.*

At the present time Mr. Horsley's statements have neither been

* *British Medical Journal*, 1884, vol. i. p. 166.

negatived nor supported, and although his specimens, in the opinion of some authorities, agreed with his description, there were others who did not think so.

Connection of the Nerves with the Spinal Cord.—As before stated, the nerves are connected to the spinal cord by two roots, the fibres from which pass into the substance of the cord, and are variously connected with its constituent parts. It may briefly be said that the fibres of the posterior root decussate with those of the opposite side almost immediately, while the motor fibres ascend in their own lateral half of the cord as far as the anterior pyramids before decussating, many of them being connected with the large ganglion cells.

The physical properties possessed by the nerve-trunks remain to be considered. Composed as each one is of a number of nerve-tubes, each separated from the other by a special sheath, and surrounded and bound together by fibrous tissue, the nerve-trunk bears a strong resemblance to the traditional bundle of faggots whose unity constituted their strength. The toughness and elasticity of the nerve-trunks is indeed remarkable, and well illustrated by the power they possess of resisting injuries, a power which is only equalled by the blood-vessels. Many instances of this must occur to every surgeon.

The Sympathetic System.—The sympathetic being removed in great part from risk by injury, needs but very brief notice. It consists of symmetrical chains of ganglia lying along each side of the bodies of the vertebræ, and connected together by intervening nerve cords. These ganglia receive branches from the spinal nerves, and themselves give off filaments to the anterior and posterior roots, more especially to the ganglion on the latter.

The nervous supply of the viscera is mainly derived from the sympathetic, the branches of which form their chief plexuses, the cardiac, the solar, and the hypogastric. The fibres which constitute the cords of the sympathetic are chiefly of the class before described as fibres of Remak, or non-medullated fibres, but, in addition, a few medullated fibres exist, originally derived, in all probability, from the branches of communication from the cerebro-spinal nerves. In addition to fibres, the nervous system contains cells varying in shape and structure, but yet having a general similarity to each other; they are found in the ganglia of the sympathetic, and in the grey matter of the cord and encephalon,

and consist of a protoplasmic cell body, in which a fine network of fibres may often be seen, containing a nucleus and nucleolus. They possess one or more processes which either interlace with those from other cells, or else are connected with the axis cylinder of a nerve-fibre, the precise relation of this fibre to the cell being still in dispute, though not apparently a matter of any material importance.

The recent investigations of Gaskell tend to show that the sympathetic system is really but a part of the cerebro-spinal nervous system already described, and that it should be considered as merely a development of the splanchnic or visceral branches of the spinal nerves.

CHAPTER II.

PHYSIOLOGY OF THE NERVES.

IN the following chapter an attempt has been made to lay stress on those points which are of special importance as regards the pathology of the nerves, with the view of saving much needless repetition in the future, but it has not been considered a fit place in which to discuss the many theories which are so efficiently treated in various works on physiology.

The function of all the nerves is essentially that of a conducting medium between the cerebro-spinal centres and the parts to which their peripheral terminations are distributed. The conducting power possessed by the nerve elements is known as their "conductivity." It may be exerted in various ways.

The only part of the nerve which is essential for the exercise of this peculiar property is certainly the axis cylinder, the remainder of the fibre acting either as an insulator of the nervous current or else as a protection for the more delicate central axis. The loss of the medulla and sheath of Schwann as the fibre approaches its termination, and the total absence of them in the non-medullated fibres, affords abundant evidence of the correctness of this view.

The fibres which enter into the formation of a nerve-trunk are generally described as centripetal and centrifugal, according as the current by which they are *usually* excited passes towards or away from the nervous centres. For this reason also they are sometimes called "afferent" and "efferent"; and further, an afferent nerve coming from a sensitive surface, such as the skin, is commonly described as a "sensory nerve," while an efferent branch supplied to a muscle is known as a "motor nerve," these names being obviously given on account of the *result* caused by the excitation of their conducting power.

In the spinal nerves, both afferent and efferent fibres exist, and the name of "mixed nerves" is therefore given to such trunks.

As the branches of a mixed nerve approach the spinal cord, the sensory and motor filaments are separated from each other, so that all the motor or efferent nerves are collected into the anterior or "motor" root, all the sensory or afferent into the posterior or "sensory" root.

This general statement as to the separation of the different kinds of fibres from each other requires some modification, for it has been found by experiment that some of the fibres of the posterior root, after running a short way in the mixed trunk, take a recurrent course amongst the motor fibres back to the spinal cord, and are therefore named recurrent fibres. Whether or not the branches from the two roots are intimately intermixed throughout their distribution, or whether they follow different paths in any individual trunk, is doubtful. A strong argument in favour of the former is that, when the branches of either root have undergone what is known by the name of the "Wallerian degeneration" (so that they can be distinguished from the undegenerated fibres), they may, as a rule, be seen commingled with the fibres of the other root, and inseparable from them except by their altered contour. On the other hand, the fact that the motor branches may be destroyed by an injury which apparently leaves the sensory nerves intact, is adduced in favour of the argument that they run a different course. The evidence thus obtained is, however, open to many fallacies, as we shall find when we come to study the pathological conditions resulting from injury.

As to the normal electrical condition of a nerve there is yet much dispute, and here it suffices to say that two main theories are at present held with regard to the presence or absence of any continuous current; Du Bois-Reymond and his followers arguing that a "natural nerve current" is constantly passing from the interior to the exterior of the nerve-trunk, while Hermann contends that all currents demonstrated by experiments are due to injury inflicted on the tissue.

What is, however, of more importance is that "neural" currents are pretty constantly passing from the periphery to the centres and so keeping up a communication as to the conditions of the peripheral parts, while others pass centrifugally, maintaining the condition of "tone" in the various muscles, and supplying the necessary neural stimulus to the glands and other organs. It is also noteworthy that this condition of tone is probably to a great extent maintained by reflex action due to the irritation of the

peripheral afferent nerves, for it has been shown by Brondgeest that if a frog be vertically suspended after the brain has been separated from the spinal cord, and then the posterior roots of the nerves supplying one leg be divided, the result is that the leg on the affected side immediately drops, showing a sudden relaxation of the muscle tone, evidently due to the want of afferent currents.*

Whatever may be the result of investigations as to the presence of the "natural nerve current," all experimenters are agreed that the changes which accompany a nervous impulse are transmitted equally well in either direction in both sensory and motor nerves,† thus making it probable that in any individual axis cylinder a nerve-current can pass, either centripetally or centrifugally, and that on a stimulus being applied to any given point of the same it is probably propagated both upwards and downwards.

Several other circumstances go to prove the same facts, which for a motor nerve is best instanced by an experiment known as the "paradoxical contraction of muscle,"‡ and is conducted as follows: A motor nerve is selected which, like the sciatic of a frog, divides into two branches. If then one branch and the attachment of the sciatic to the cord be divided, it will be found that on irritating the central end of the divided branch, the electrotonic state is developed, not only in the portion of the trunk continuous with the irritated fibres, but also in the other branch, as will be made apparent by the contraction of the muscles supplied by the latter. In this case the nerve-current must have passed up the divided nerve as far as its junction with the other branch, before it could have caused a muscular contraction.

For a sensory nerve the same fact is proved by the experiment of M. Bert. The tip of a rat's tail was bent over and engrafted into the skin of the back, and subsequently the root was divided. A year later, irritation of the root gave rise to symptoms of pain, the impressions causing which must have been conveyed in a direction exactly the reverse of normal. The sensitiveness acquired by the flaps some time after many plastic operations would tend to prove the same, while the study of the return of sensation after neurotomy will supply additional examples of a fact that is of much importance to the study of neural pathology.

* Hermann's *Physiology*, p. 488.

† Foster's *Physiology*, fourth edition, p. 106.

‡ Carpenter's *Physiology*, second edition, p. 343.

The rate at which the nervous impulse travels appears to be much the same for both motor and sensory fibres, probably in the frog about 33 metres per second; and it was the result of a consideration of this, and the above-mentioned similarity in the behaviour of motor and sensory nerves to the same electrical stimuli, that led various experimenters to try and establish a functional union between sensory and motor trunks. Full accounts of these attempts, especially as regards union of the hypoglossal with the lingual, may be found in all works on physiology, and we may briefly say that in the opinion of the experimenters themselves (Vulpian and Philippeaux) the functional union of motor and sensory trunks remains to be proved.

Nerve Stimuli—The various stimuli which excite, and the condition of the nerve which is favourable to the passage of a nerve current, remain to be considered.

The most notable of all artificial stimuli is electricity, which excites not only the sensory nerves, but is more powerful in causing active contraction of muscle than any other stimulus of which we have knowledge. The effects differ according to the nature of the current. A continuous current up or down a nerve causes muscular contractions at the moment of opening or closing the current, or else when any sudden change is made in its intensity, while the same stimulus applied at right angles across the nerve-trunk produces no appreciable effects. With an interrupted current the muscles rapidly pass into a tetanic condition. It was through an observation of such phenomena that the law of Du Bois-Reymond was promulgated, a law which holds good for all kinds of stimuli, and which may be stated as follows—"The excitation of a nerve is affected by the *modification* rather than by the actual intensity or *amount* of the stimulus."

This is instanced by the muscular contractions called forth by the making and breaking of the current, and not by its passage; also by the same results occurring when any sudden *change* takes place in the intensity of the current.

This law is equally applicable to the effects of any other stimulus, and therefore to that which holds one of the most important places after electricity—namely, mechanical irritation. For though a sharp tap be quite sufficient to excite muscular contraction, a nerve may sometimes be completely destroyed by very gradually applied pressure without any effect being visible in its supplied muscle, a fact of much importance in pathology. Various chemical agents act as

stimuli to the nerves, as do also heat and cold, though whether to all nerves equally is not quite clear.

In order that a nerve may conduct efficiently, it is necessary that it shall be supplied with a proper quantity of blood, and, further, that this shall be of proper quality. The result of the absence of a sufficient blood-supply is well shown in the numbing effects of cold, and in similar conditions occurring after the application of a ligature to the main vessel of a limb. Any alteration in the amount of water contained by the nerve alters its conducting power, but, within certain limits, this power returns if the nerve be placed in circumstances favourable for the restitution or otherwise of the required moisture.

Applications of cold to a nerve-trunk at first excites the conducting power, but afterwards destroys it; further mention of this will be made in connection with the congestion of nerves.

In order that sensation of any kind shall be duly appreciated by the nerve-centres, it is essential that the proper terminal organ shall be excited, and not the nerve-trunk itself. Thus, it is well known that if any sensory trunk be irritated, the sensation is referred to the whole of the peripheral distributions of the nerve as well as to the part struck, and this must be borne in mind in considering the pathological conditions which cause pain.

The skin is specially adapted for the due development of the sense of touch and temperature, and its integrity is a necessary factor for the proper appreciation of the same; thus, in the seat of a scar, or else of an abrasion, these senses are numbed or else entirely in abeyance.

It is unnecessary in this place to do more than refer to the theory of the sense of touch, as excited by a mechanical stimulus—namely, that the delicacy of touch depends on the fact that each nerve fibril supplies a certain skin area whose relative size and closeness to each other differ in different regions of the body. It is further supposed that the Pacinian corpuscles and other bodies found at nerve terminations intensify the impressions.

It is, however, very necessary that the respective sensibility of different parts of the body should be known in order that a certain standard of health may be established, and the amount of departure therefrom in pathological conditions duly measured. The minimum distance at which two points of a pair of compasses can be distinguished as such, is the usual test of tactile power. These

distances vary in different parts of the body, and are given by Weber as follows :—

	Millimetres.
Tip of tongue	1.1
Palmar surface of last phalanx of finger	2.2
Palmar surface of second phalanx of finger	4.4
Tip of nose	6.6
White part of lips	8.8
Back of second phalanx of finger	11.1
Skin over malar bone	15.4
Back of hand	29.8
Forearm	39.6
Sternum	44.0
Back	66.0

The following in inch measurements are by Dr. Graves, a line being 1-12th of an inch :—

	Lines.
Point of tongue	$\frac{1}{2}$
Palmar surface of third phalanx	1
Palmar surface of second phalanx	2
Palmar surface of metacarpus	3
White parts of lips	4
Palm of hand	5
Tip of great toe	5
Dorsum of hand	8
Skin over patella	16
Sacrum (skin over)	18
Acromion (skin over)	18
Dorsum of foot	18
Middle of thigh	30

Sense of Temperature.—In addition to the sensations caused by mechanical stimuli, the skin has the power of conveying sensations of heat and cold, and of distinguishing with some accuracy the variations of temperature. The question has been raised as to whether or no these sensations are carried by nerve-fibres separate from those which convey the sensations produced by mechanical stimuli, and whether there are two kinds of peripheral organs, each of which is affected by its own stimulus alone, and is connected with a separate centre of perception.

It is urged against this view that when each stimulus is brought to bear in a very limited area, the two sensations are frequently confounded, “and the cases where a hot sponge or spoon was felt because it was hot, and yet the sensation was confounded with one of pressure, indicates that the same terminal organs are affected by both stimuli.”*

* Foster's *Physiology*, second edition, p. 531.

It is also evident from the study of nerves which are uniting after division, that the power of the nerve to conduct sensations of heat requires a more perfectly normal state than that necessary for the excitation of tactile perceptions, for the latter are almost always present before any sensation of heat can be established.

Sense of Pain.—The same claims that have been made for special nerves and nerve-endings to conduct the sense of heat and cold, have been also made for the conduction of the sensation of pain.

As a result of the study of pathological conditions, Brown-Séguard * stated his belief in the presence of separate conductors for "touch," "pain," "tickling," and "temperature," and his arguments have been supported by others. This hypothesis seems to me to be quite unnecessary, and there is really no reason why the same nerve-fibres should not be capable of conveying *various* impressions which can be appreciated by the nerve-centres. We know that the contraction of a muscle can be excited by the application of *various* irritants to its motor nerve, and as far as I am aware no one has yet suggested that each stimulus requires a separate set of fibres to produce its due effect. Why then should we think it necessary to invent the same for the conveyance of sensory impressions? It is, in fact, the intensity or amount of the stimulus that determines the painful sensation, and of course, if the centre which appreciates the stimulus be itself in a highly excitable state, the amount of the stimulus required to produce the sensation is diminished: this is instanced by the different susceptibility of different persons to the sensations of pain, and also by the hysterical state. Again, the fact that as the result of a nerve injury there is never complete anæsthesia, whilst the sense of pain remains intact, argues the same conclusion; the contrary fact, that pain may be absent yet tactile sensation perceived, is open to the same explanation that I have offered for the absence of the thermic sense under similar conditions—namely, that a more perfect condition of the nerve-fibres is requisite for the conduction of pain than for that of touch; or, in other words, that the stimulus which is sufficiently strong to excite tactile sensation is not of enough intensity to cause pain. This is again instanced in the case of the nerves of special sense. A moderate stimulus applied to the peripheral terminations of the

* *Archives de Physiologie*, 1868.

optic nerve causes a sensation of light, while one of very great intensity will cause pain.

But if the argument be allowed that two sets of nerves exist—one for pain and the other for touch—we must suppose that the point of a needle which causes either tactile or painful sensations, according to the pressure applied, must always cover an area sufficiently large to include both a tactile and painful nerve-ending. This theory appears to me to be quite untenable.

Muscular Sense.—The actual nervous mechanism of what is known as “the muscular sense” is probably very complicated. Whether it is of central or peripheral origin has been much disputed; but the latest investigations tend to prove that it is largely dependent on sensations conveyed from the periphery, as well as on what may be called the neural sense, caused by changes in the encephalon, as a result of the exercise of volition.

In support of the latter, the observations of Mitchell * are very interesting. He quotes various cases in which a patient expressed his ability to appreciate the apparent position of muscles in a part which had been amputated, saying, “My hand is now open; I touch the thumb with the little finger,” &c., when only the stump of an arm remained. In such cases, the attempt or desire to place the muscles in certain positions also conveyed the idea that the will was obeyed.

On the contrary, I may mention the case of a man who received a severe blow on the side of the neck, resulting in complete hemi-anæsthesia below the third cervical vertebra. Combined with this condition was an equally complete loss of muscular sense, but not of muscular power. If his leg was put up in the air, he easily retained it there, but was not aware of its position; both extremities could be placed similarly in various stages of contraction or extension, in which they were retained without the knowledge of their owner. This patient subsequently recovered entirely. I offer no explanation for these cases, and would formulate no theory thereon. The whole subject requires further investigation.

* *Injuries of Nerves*, p. 558.

CHAPTER III.

CHANGES IN NERVES AFTER SECTION, THEIR DEGENERATION AND REPAIR.

IN considering the pathological conditions to which nerves are subject, it will be advisable to commence by a study of the changes which occur in the peripheral and proximal ends of any mixed nerve after simple section.

With regard to the peripheral end there is now tolerable unanimity, in one respect at least, as all writers concur in describing a degeneration of both motor and sensory fibres, whilst differing in their description of the process. Waller, in 1862, first thoroughly investigated the effects of division, and established these facts.

1st. That section of the anterior root, before its junction with the posterior, resulted in a degeneration of that part of the motor fibres which are thereby separated from the cord.

2nd. That section of the posterior root, on the proximal side of its ganglion, resulted in a degeneration of that part of the fibres only which intervened between the point of section and the cord, while the periphery of the nerve remained intact. Waller therefore concluded that the ganglion cells of the cord formed a trophic centre for the nerves of the anterior root, while the ganglion on the posterior root fulfilled a similar office for the sensory fibres.

These conclusions are generally allowed to be correct, as are also the facts from which the author deduces them, despite the difficulty of explaining the *regeneration* which, we shall presently see, occurs while the distal end is still separated from its trophic centre. In the above experiments the recurrent nerve-fibres present in all nerve-trunks may be seen for some time in a normal state in the *peripheral* segment, while in the proximal end of the divided nerve some may be seen in a degenerate condition. The recurrent fibres soon undergo atrophy.

While agreeing in the main as to the changes occurring in the distal end of a divided nerve, the various authors who have inves-

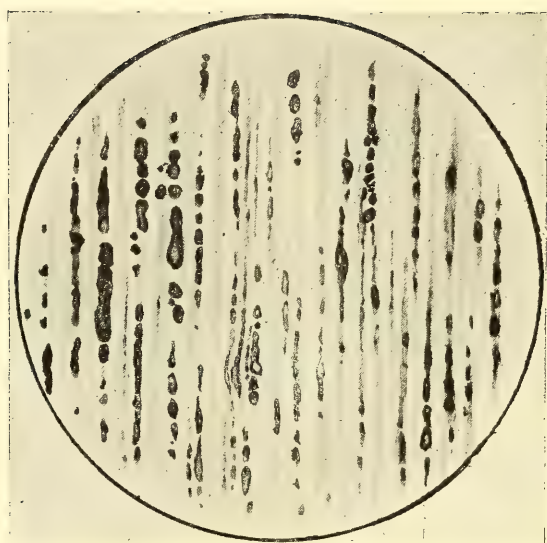


Fig. 3.

FIG. 3.

Longitudinal section of the degenerate lower end of a nerve fifteen days after section. The specimen has been prepared in osmic acid, and the myelin, which has stained black, is broken up into drops of various size.

tigated this subject differ in the details of the process, and it will therefore be advisable to quote here the most important of these conclusions. Waller and Busch* believe that the whole of the primitive fibrils are destroyed and are regenerated by reunion with the proximal end. Ranvier† describes a swelling-up of the nuclei of the sheath of Schwann, the protoplasm of which collects into large masses, and encroaches upon the sheath of myeline. The swelling commences within twenty-four hours of division, and by the third day the pressure of the newly formed mass has resulted in a complete section of the axis cylinder opposite the situation of the nucleus in each of Ranvier's nodes. By the sixth day the myeline is reduced to small fragments, the protoplasm contains fatty granules, and the nuclei of the sheath are increased in number; finally, at the twentieth day the fragments of myeline settle into masses, separated from each other by slender filaments with oval nuclei, formed by the sheath of Schwann. At the same time granulo-fatty degenerative changes are observed in the connective-tissue cells and in the endothelium lining the vessels, the fat granules being probably derived from the myeline which passes in a state of solution through the sheath of Schwann. White blood-cells become infiltrated into the substance of the nerve-tubes and appear to be instrumental in removing the débris.

Mitchell‡ describes a loss of translucency from the fourth to the sixth day, and says that the white substance of Schwann undergoes an irregular segmentation, and finally disappears, the nerve assuming a dull grey tint, like a piece of firm connective tissue. While confessing the difficulty of arriving at a very satisfactory conclusion, he considers that the axis cylinder is probably not affected by the process of degeneration. He does not think that this process spreads gradually from the cut end of the nerve to the periphery, but is satisfied that it affects at one and the same time the whole length of the nerve.

Benecke § agrees with Mitchell that the degeneration affects the whole periphery simultaneously, and that the latter becomes of a cloudy yellow tinge and tears easily. The medullary substance coagulates and breaks down to a fine detritus, the axis cylinder

* *Zeit. für Wis. Zool.*, 1854, vol. vi.

† *Compt. Rend. de l'Acad. des Sci.*, 1872; and Cornil and Ranvier's *Pathological Histology*, 1882.

‡ *Op. cit.*

§ *Virchow's Archiv*, 1872.

becomes enlarged and swollen, and finally disappears, and the nuclei of the sheath multiply.

MM. Cossy and Dejeune consider that the large nerve-fibres do not degenerate so rapidly as the fine primitive fibrils, and that till the third day the only change is that the axis cylinder is abnormally friable and the nuclei of the sheath are swollen. Changes in the medullary sheath (similar to those already described) commence on the fifth day, and are considered by these authors to be secondary to those which occur in the axis cylinder; the latter entirely disappears by the twelfth day.*

Leegard investigated the condition of the distal ends of nerves after having produced a simple solution of continuity of the myeline and axis cylinder and not of the sheath, by the application of a ligature which was immediately removed. He found that in three days the axis cylinder broke up in places whilst the myeline ran together into cylindrical masses and ultimately underwent a granular degeneration; the nuclei enlarged and multiplied, and the axis cylinder finally disappeared from the tenth to the fifteenth day. This process of degeneration attacked the whole peripheral segment at once.†

In two cases in which I have had the opportunity of examining the nerves, one on the fifteenth day after injury, and one on the thirtieth, when operations for the purpose of secondary suture were undertaken, the condition of the peripheral end was very satisfactorily demonstrated after staining in osmic acid.

In the case in which the nerve had been divided fifteen days previously, there was found much segmentation of myeline, which had collected in droplets of varying size in the nerve-sheaths. In most of the sheaths there was some myeline, but in a few it was completely absent.

The nuclei of the sheath had increased in number, although not to any great extent.

The condition of the axis cylinders was very difficult to establish with certainty. In most parts of the sections they had completely disappeared, and it was only after a very prolonged search that I could satisfy myself that some of them were yet present, though so much altered in contour as to be almost indistinguishable.

In the case in which the section was thirty days old, the changes mentioned above were all further advanced. Only a few drops of

* *Archiv. de Phys.*, 1876.

† *Archiv für Klin. Med.*, 1880.

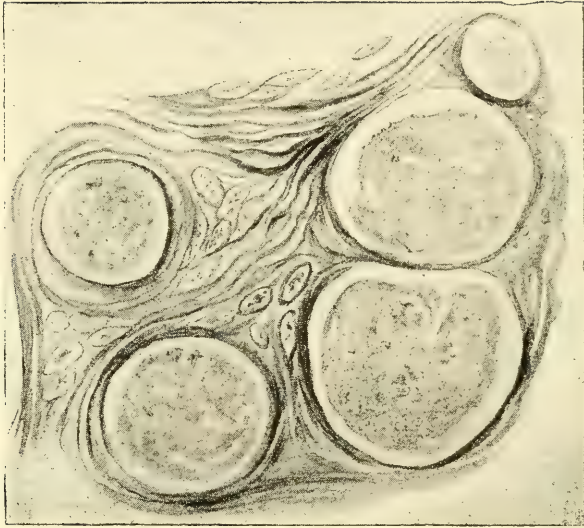


Fig. 4.

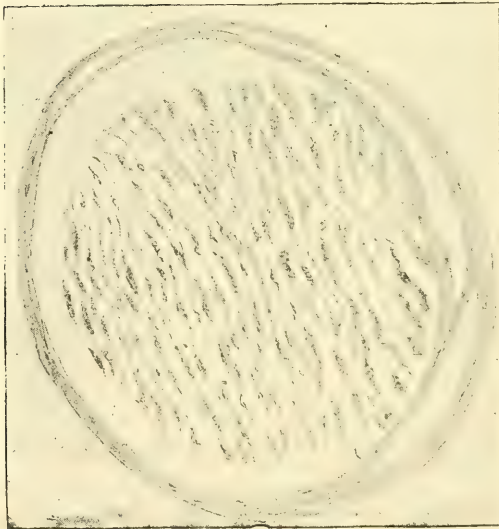


Fig. 5.

FIGS. 4 AND 5.

Transverse sections of the degenerated lower end of a nerve several weeks after section. The nerve-tubes can no longer be distinguished, and their atrophied remains no longer fill the sheath of perineurium.

myeline remained, the axis cylinder had entirely disappeared—or at any rate could no longer be distinguished—whilst the nuclei of the sheath were again but slightly increased in number.

In another case, I examined the peripheral end of a divided nerve three months after section. Here it was impossible to recognize any nerve-tubules at all. There was a complete absence of myeline and of axis cylinders. In cases examined at times varying from three to six months after injury, similar appearances are found. In the majority of such specimens, the places formerly occupied by nerve bundles are marked by the presence of circular masses of tissue, which have the appearance of connective tissue with many nuclei. These masses are, however, much smaller than the healthy nerve bundles, and consequently do not fully occupy the space in the perineurium, but appear to have shrunk away from the surrounding tissue.

My own observations on human nerves would thus appear to accord with those of other observers on the nerves of animals, and it may be concluded that the degenerative changes are signalized by the destruction of the myeline, the multiplication of the nuclei, and the loss of continuity of the axis cylinder. The greater number of observers, and amongst them the most trustworthy, are also agreed that these changes occur in the whole length of the peripheral portion at one and the same time, while others maintain that they commence at the cut end and spread downwards, either a short distance from the point of section, or else along the whole periphery. This degeneration commences within a day or two of the injury, and within two or three weeks the nerve has undergone complete atrophy.

Central End.—As has already been mentioned, the fibres of the proximal end are but slightly affected by the nerve section. Ranvier describes the changes as being limited to one, or at most two, of the inter-annular segments, and says that the myeline, instead of becoming broken into large fragments, which subsequently become smaller, as in the peripheral end, is rapidly reduced into fine granules, which later on assume a yellowish-brown colour with osmic acid. The nuclei multiply and increase in size, but instead of encroaching on the medulla they remain flattened against the sheath of Schwann; the axis cylinder remains intact. An infiltration of white blood-cells into the nerve substance occurs, similar to that already described in the peripheral segment.

Neumann also describes somewhat similar changes.

Leegard* describes changes similar to those which he noticed in the peripheral end as occurring in the first inter-annular segment of the proximal end, the next three or four segments becoming also irregular and shorter. The sheath is empty at places and shows nuclear proliferation.

Bulbs.—It is now many years since it was noticed that after section of a nerve the upper end became bulbous, and this has more particularly excited observation in stumps. The very general opinion as to the structure of these tumour-like swellings in the nerves is that they consist of fibrous tissue, a statement which has been handed down from one author to another without apparent investigation.

George Hayem, in 1877† was the first to point out that these bulbs consist not only of newly formed fibrous tissue, but also of new nerve elements. He believes that after amputation the most distal portion of the cut nerve degenerates, and is replaced by young fibres, which undergo a gradual process of development.

In a case which I have recently examined, the amputation (through the leg) had been performed five years previously in a lad aged twelve years. Re-amputation became necessary on account of an insufficient covering for the bones, and an examination of the bulb on the anterior tibial nerve showed on cross section a greater number of fibres than did the healthy nerve above. The only conclusion that can be arrived at is that the additional fibres were of new formation; they were mixed with newly formed fibrous tissue.

A microscopic examination of such a bulb under a low power shows a proliferation of the perineurium, which penetrates between the different fibres in the bundles and separates them into smaller bundles of three, four, or more fibres. Later on, these fibres becoming compressed, gradually lose their sheath of myeline, and so appear smaller than normal. The lower down in the bulb the section is made the more complete do these changes appear, so that between this part and the junction of the bulb with the healthy nerve above all stages of transition between connective tissue and healthy fibres may be seen.

Considering that the young nerve-fibres also appear on section to be smaller than normal, it becomes very difficult to say for certain whether any individual nerve-tube is in a stage of transition

* *Op. cit.*

† *Rev. des Sci. Med.*

FIGS. 6 AND 7.

Transverse sections through a bulb, showing the numerous bundles of small nerve fibres under a high and low power.

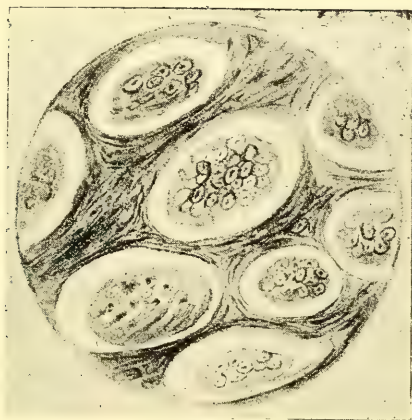


Fig. 6.



Fig. 7.

into a higher or lower state. Nevertheless, as a transverse section shows on careful examination that although some of the thickness of the bulb is due to an increase of the connective-tissue elements, yet the larger amount of it is composed of nerve-fibres, we are naturally driven to the conclusion that some of these must be of new formation. Sections of the nerve trunk above the bulb do not usually show any of the degenerative changes that are met with in the peripheral end, there being no increase of connective tissue or decrease in the white substance of Schwann unless inflammatory changes have been started and "chronic neuritis" has supervened. In those cases, however, where the section is of very long standing, it appears that after the lapse of a considerable time, probably years, the nerve-fibres do in part atrophy and degenerate, and thus follow the example of other tissues, and bear evidence to the general truth of the pathological law that "atrophy results from disuse." I have not myself had opportunities of examining the proximal ends of divided nerves at any distance from the seat of injury after simple section, but I have examined the nerves from limbs in which amputations have been performed in bygone years, and have found in them that many of the nerve fibres are diminished in size, that their myeline sheath is greatly shrunken, and that some of them have quite disappeared. This is a pathological fact of the greatest clinical interest, and one to which I shall again have occasion to refer.

Regeneration and Union.—The process of degeneration, which has just been described, is succeeded by one of regeneration, resulting, in favourable cases, in a complete restoration of the nerve. The exact manner in which this process is described by various authors is so different that it will be as well to quote their description first, and subsequently to draw conclusions not only from the pathological changes which may be seen under the microscope, but also from observation of clinical cases. As I have not had any opportunities of examining nerves during the process of primary union, I am obliged to accept and base my conclusions to a great extent upon the experiments on animals made by others; the further changes, however, which occur in the distal end, and which I have not yet described, I have been able to investigate for myself.

Chief in importance amongst these is the regeneration which occurs even when no union has taken place with the proximal end, for an examination of the peripheral end, seven or eight months

after section, will show that the axis cylinders have been re-formed, and that around them a deposit of myeline is slowly developing. The fibres are not, of course, collected into symmetrical bundles as in a healthy trunk, and are smaller than natural. They may be seen scattered about amongst the surrounding connective tissue in all stages of development, some of the axis cylinders yet naked, others with varying amounts of myeline around them. It seems strange that such regeneration should take place without reunion with the nutritive centre, but the importance of the fact for a proper appreciation of the symptoms and results of nerve sections, as well as for the light it throws on the question of treatment, makes it one of much interest.

As to the exact process by which these new nerve-fibres are formed, and the divided end reunited, I shall first refer to the following accounts by others.

So long ago as 1855, Lent* stated his opinion that the new nerve-fibres were formed from the nuclei of the sheath, but does not appear to have actually observed the process of formation.

In 1860, Hjelt† expressed his concurrence with the opinions of Lent. Investigations by Remak further tended to confirm the fact that the new nerve-fibres were developed in connection with the sheath of Schwann, and this observer also noted that in some cases several axis cylinders might be found within a single sheath in the peripheral part of the divided nerve.

According to Neumann, new nerve-fibres are formed by a longitudinal splitting of the axis cylinders which are left undegenerated, the new fibrils being subsequently covered with myeline. He also has observed several axis cylinders in a single sheath. Ranvier‡ describes the method of regeneration very minutely. He maintains that regeneration takes place by a growing downwards of the axis cylinders of the proximal end, which split up into a brush of small nerve fibrils as far as the first node. These fibrils grow towards the lower end, either into or between the degenerated tubes, and form an uniting cicatrix. He admits that in the interior of the degenerated peripheral fibres there is an appearance of two or more axis cylinders, as described by Remak and Neumann, but maintains that they are the result of an ingrowth from above, and are not simple axis cylinders but perfect nerve-fibres, each with its sheath of Schwann. Regeneration of the

* *Manual of Pathology*, Wagner, p. 424.

† Virchow's *Archiv*.

‡ *Op. cit.*, and Cornil and Ranvier's *Pathological Histology*, trans. 1887.

lower end does not occur until after its union with the upper. The inter-annular segments of the new nerve-fibres are much shorter than those of the older ones.

Dr. Korybutt-Daszkiewicz, of Strasburg,* says that the degenerative changes do not, as a rule, go beyond the first of Ranvier's nodes in either the peripheral or proximal ends. "After the liquefaction of the old medulla in the central end, there occurs the formation of a new myeline with the peculiar appearance that between two former constrictions one or two new ones are formed. The nuclei of the sheath of Schwann also undergo changes in the central end, near the division of the nerve; they swell up, become surrounded by granular protoplasm, and, after becoming separated from the fibres, assume an elongated form; whether finally developing into nerve-fibres could not be definitely ascertained. The axis cylinders in the peripheral part break up into more or less numerous fragments during the segmentation of the medulla, and of these some apparently liquefy and participate in the same changes as the myeline, while others persist and clothe themselves with a new medullary sheath." "Before the degenerated myeline began to lessen, the fragments of axis cylinders began to lengthen in each direction, the nuclei persisting within the sheath began to elongate and lay at certain distances from each other. Simultaneously with this process, the new medullary sheath made its appearance as a varicose or uniform deposit upon the axis cylinder. Thus the fragments of axis cylinder remaining serve as a starting-point for a new endogenous formation of nerve-fibres. They present no tendency to blend with one another, but remain in contiguity, growing in the same general sheath, close to one another, and ultimately, after the disappearance of the old sheath of Schwann, they develop into independent fibres. Hence, at a certain time, there is an appearance as of several nerve-fibres in a single sheath."

"If, however, after a division of a nerve the axis cylinder remains intact in its entire length, and the medullary sheath degenerates, the appearance of several fibres in the same sheath is never seen."

Benecke† says that the nuclei of the sheath, which, during the process of degeneration are seen to multiply, elongate and form axis cylinders by joining to each other in the long axis of the nerve.

* *Lancet*, Sept. 21, 1878.

† *Op. cit.*

Around these new cylinders the medullary substance and sheath of Schwann are subsequently applied. With this description Bakowiecki's observations entirely coincide.*

Leegard† considers that the process of regeneration starts in the protoplasm accumulated within the sheath in the neighbourhood of the nuclei, fine greyish threads becoming differentiated in the inter-annular segments and running together into a continuous fibre; the new segments appear shorter than those in the healthy nerve. Several new fibres do not originate in a single one, and the regeneration is more rapid the nearer the lesion is to the periphery. Glück‡ describes union as occurring by means of an elongation of the already multiplied nuclei, the myeline and sheath of Schwann being formed at a later date. The investigations of this observer will be again referred to.

The descriptions of these various authors are all the result of experiments on animals, and considering that there is frequently found to be some difference in the exact mode of degeneration and regeneration in different animals, it is necessary, or at least advisable, to trace the same process in man.

I have already alluded to my examinations of nerves in a state of degeneration, and shall now describe the appearances I have met with in three cases, in which regeneration of the peripheral end had occurred after section, independently of union with the upper portion. These cases are described in full in the chapter on Nerve Suture, and at present I shall refer to the microscopic examination alone.

The first case was that of a lad, aged eighteen, in whom an operation for reunion of a divided ulnar nerve was undertaken seven months after injury.

An examination of the portion of the peripheral end, which was removed preparatory to suture, showed that, scattered throughout a transverse section, were several small, imperfectly developed nerve-fibres, such as are met with, and have already been described, in the bulbous proximal end. These new fibres were not collected into definite bundles, they were much smaller than natural, and their myeline sheath was scarcely perceptible. The total number of these new fibres was but small, and I was unable to trace their development in a satisfactory manner.

The second case was that of a woman, aged fifty-three, who had

* *Gaz. Med. de Paris*, 1876.

† *Op. cit.*

‡ *Virchow's Archiv*, 1878.

FIG. 8.

Longitudinal sections through the lower end of a divided nerve nine months after section, showing the early formation of new nerve fibres from the nuclei of the sheath. (Crouch, $\frac{1}{8}$ in.)

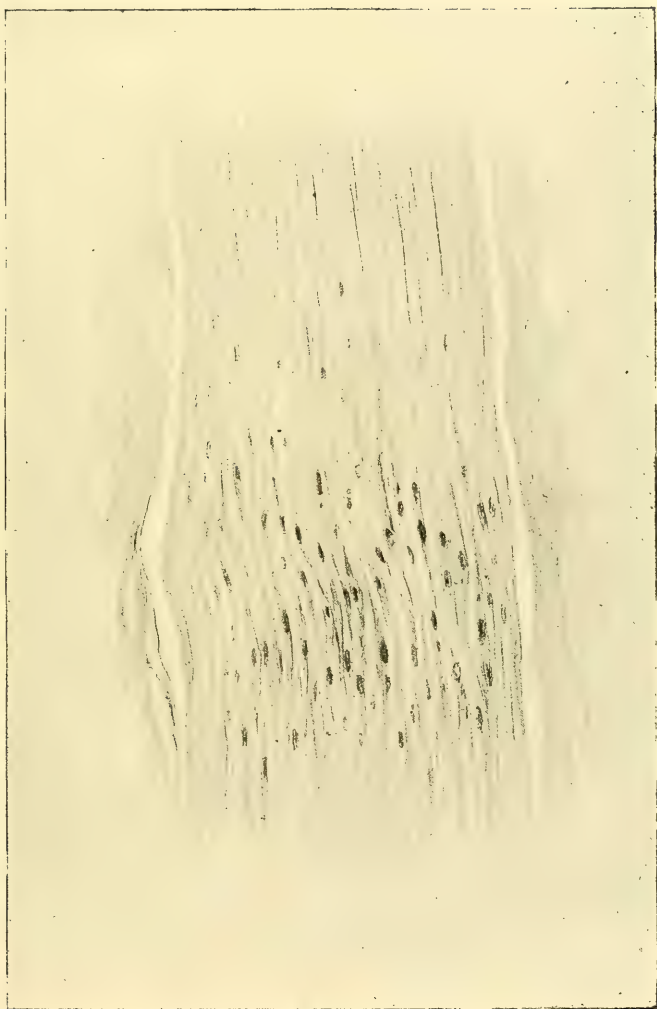


Fig. 8.

divided the median nerve just above the wrist-joint. An operation for reunion was undertaken nine months later, and the condition of the resected portion of the peripheral end was found to be as follows :—

The circular spaces in the neurilemma, which I had previously found in other degenerated nerves partly filled with nucleated connective tissue, I now found to be occupied by nerve-fibres in varying stages of regeneration. The steps in the formation of these fibres could, moreover, be most clearly traced.

Their first appearance was in the form of oval and spindle-shaped nuclei, which seemed to be identical in structure with the nuclei of the sheath. These nuclei were arranged in bundles with their long axis parallel to that of the nerve-trunk.

The next step was the elongation of the nuclei and their gradual transformation into fibres, around which, subsequently, a myeline sheath was formed. In some parts of the section bundles of newly formed nerve fibrils could be seen occupying the spaces in the neurilemma, which had evidently been previously occupied by the healthy nerve bundles before the time when the injury was inflicted.

The new fibres in some bundles were in a much more advanced stage of development than those in others, the regeneration appearing to proceed simultaneously throughout all the tubules in each bundle, irrespective of the condition of the fibres in others.

I have been unable to find that similar changes have been noticed by other investigators in cases of nerve sections in man, and have also had the opportunity of examining the nerve ends in a case in which the ulnar had been divided nearly two years before I saw the patient.

The nerve had been completely cut across and no union had taken place, the upper and lower ends being separated by about half an inch or more of firm cicatricial tissue.

A microscopical examination of the peripheral end showed that many of the fibres had been regenerated. A large number of the bundles contained numerous nerve-fibres in various stages of development. In some the axis cylinder alone was formed. In many others the myeline sheath surrounded the young axis cylinders, whilst in some the "nodes of Ranvier" were well marked.

The accompanying drawings show these conditions very plainly.

There is indeed a tolerable consensus of opinion as to the part

played by the nuclei of the sheath, from which, according to most authors, the new axis cylinders are formed. The strongest objection to Ranvier's theory, that the undegenerate fibres of the central end grow into the empty sheath of the periphery, lies in the fact that, as I have already described, the peripheral end will regenerate even when ununited to the central healthy fibres. And if further proof of this be necessary, it may be found in the investigations of Philippeaux and Vulpian,* who not only saw regeneration of the peripheral fibres without union with the proximal end, but found the same take place in a piece of nerve resected and transplanted into the surrounding tissues. If then the peripheral end has become regenerated, and is placed in sufficiently close proximity to the central portion, union will result by the continued formation of nerve-fibres between the divided extremities. But, on the other hand, should union fail, it appears probable that the nerve again degenerates, perhaps never to recover. I have found no mention of this by other authors, but nevertheless feel certain that such changes must occur, for otherwise we should have some difficulty in explaining those cases in which, many years after injury, the nerves have been found completely atrophied. As examples of such, I append the two following examples.† Israel records the case of a man who had been shot through the median and ulnar nerves thirty-two years previously, and in whom the peripheral ends were found to have only the thickness of a knitting-needle, and to consist chiefly of connective tissue.

In volume xxv. of the Pathological Society's *Transactions*, Mr. Butlin describes a case in which the ulnar nerve had been divided fourteen years before death. No union had taken place, and the lower end was found to consist nearly entirely of connective tissue, a microscopic section showing that the healthy nerve-fibres had entirely disappeared, while the presence of any axis cylinders was very doubtful. No doubt many such cases can be found, and all bear but one or two explanations. Either the divided nerve never became regenerated at all, or else it subsequently again degenerated: the latter appears to me the most likely, but before the matter can be considered settled, more investigation is necessary.

The conclusions which may be drawn from the most recent investigations are:

* *Gaz. des Hop.*, 1861.

† Virchow's *Archiv*, vol. lxxxv.

FIG. 9.

Longitudinal section of the lower end of a divided nerve nine months after section, showing bundles of newly formed nerve fibres under a low power. (Crouch, $\frac{1}{2}$ in.)

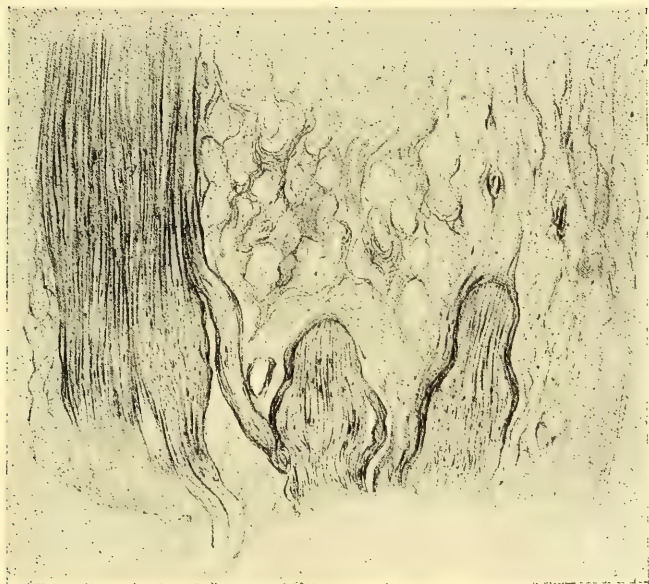


Fig. 9.

1. That the nuclei of the sheath of Schwann (which are developed from epiblast) form the new axis cylinder.

2. That the myeline is subsequently formed around the new cylinder.

3. That the peripheral end may become regenerated without forming any union with the proximal extremity, but that it again tends to degenerate if union fails.

Changes in the Spinal Cord after Nerve Section and Amputation.—It has been shown by English authors—notably by Dr. Dickinson—that certain changes occur in the spinal cord after amputation of a limb. The precise cause of this has been more clearly demonstrated by Vulpian, in a paper addressed to the Académie des Sciences. He says that after amputation of a limb, the spinal cord, at the place where the nerves are given off to the extremity which has been removed, becomes considerably lessened in all its diameters. This atrophy happens after amputation at all ages, but most rapidly in the young. There is no myelitis or fatty degeneration.

Not content with this discovery, M. Vulpian divided some of the large nerve-trunks in different animals, and after keeping them alive for varying periods, he killed them and examined their spinal cords. The amount of atrophy which he found was exactly of like extent and character to that which he had previously observed as the result of amputation. He therefore concluded that in the latter case also the wasting was due to section of the nerve rather than to removal of the limb.

Friedrich,* Genzman,† and Leyden‡ have also described the changes in the nervous system met with in cases of old amputation, and the views of these writers, as well as those of Vulpian§ and Dickinson,|| already alluded to, have been summarized by Dreschfeld¶ in a valuable paper containing the account of another case.

In his summary, Dr. Dreschfeld says:—"Changes in the trunks of the large peripheric nerves are recorded in only one case of Dickinson's. Vulpian and others, and amongst them myself, have not detected any change in the peripheric nerves. The nerve-roots, again, were found altered by Dickinson and by Leyden, and

* *Progress. Muskelatroph.*, p. 140.

† Virchow's *Archiv*, vol. lxvi.

‡ *Klinik. der Rück. Krankheiten*, vol. i. p. 316.

§ *Archiv. de Physiol.*, 1868 and 1869. || *Journal of Anat. and Physiol.*, 1868.

¶ *Journal of Anatomy and Physiology* for 1880, vol. xiv. p. 424.

seem in most of the other observations to have been unaltered. As regards the spinal cord itself, the white matter has been found in most observations (with the exception of Dickinson's and a few of Vulpian's cases) intact; the posterior grey matter has been found altered in many of the recorded cases, but has been found absent in those cases most recently reported. On the other hand, the changes in the anterior grey matter are of the most constant occurrence, and, though missed in some of the older observations, have been found in all the recently recorded cases. These changes affect chiefly the ganglia cells, and though most authors have not sufficiently distinguished between the several cell groups, a glance at the drawings accompanying the descriptions of the several cases will convince anybody that the intermedio-lateral tract of cells is the one constantly attached."

Since the publication of Dreschfeld's paper, the literature of the subject has been enriched by three papers—one by Drs. Hale White and Edmunds, in the *Transactions* of the Pathological Society (vol. xxxiv. p. 16); another by Hayem and Gilbert, in the *Archiv. de Phys.* (1884, vol. iii. p. 430); and the third by Dr. E. S. Reynolds, read at a meeting of the Pathological Society of Manchester, and mentioned in the *British Medical Journal* for February 26, 1887.

The authors of the former paper narrated a case in which a limb had been amputated six years before death. The nerves of the stump had "undergone such degeneration that they are little more than masses of connective tissue derived probably from the perineurium." This refers to the bulbous ends, but in the sciatic of a girl on whom amputation of the leg had been performed some years previously, there was noted "an increase of connective tissue between the fibres, which has in many cases so invaded them as to cause their complete destruction." No mention is made of the condition of the spinal cord.

In the second case one of the nerves was again found altered above the site of amputation. The patient was a man who had undergone an operation for amputation of the forearm immediately above the elbow seven years before his death. During the time that intervened between the operation and his death he suffered from no nervous symptoms of any kind. The following changes were found in the nerves of the stump. The ulnar, median, and radial nerves were more particularly examined. They each terminated in a neuroma. An examination of these neuromas showed

FIG. 10.

Transverse section of the lower end of a nerve seven months after division, showing some scattered nerve fibres.

FIG. 11.

Transverse section of the bulb in the upper end of the same nerve, showing the thick fibrous tissue and some bundles of nerve fibres.



Fig. 10.



Fig. 11,

that they consisted in very large part of numerous small nerve-tubules. The direction of these tubules was for the most part longitudinal. They appeared to be continuous with the normal tubes of the nerve above the bulb—that is, it seemed as if the axis cylinders broke up into numerous small fibrils which penetrated into the surrounding fibrous tissue. The radial and median nerves themselves were smaller than those of the opposite side. Their nerve-tubules were diminished in number and were also smaller than natural. This smallness was due chiefly to the absence of the myeline sheath. The axis cylinders also were very slender. There was also a slight increase of connective tissue in the nerve-trunk and the ulnar nerve was definitely enlarged. The enlargement was due in part to the increase in its connective tissue, but in part also to an increase in number of the nerve-tubes. Many of these were smaller than natural, and presented an appearance precisely similar to that met with in section of the bulb. There seemed to have been a degeneration of the nerve-tubules with subsequent regeneration. In the posterior roots there was an evident atrophy of the nervous substance. In the spinal cord also there were changes on the side on which the amputation had been performed. The posterior column was smaller than on the opposite side: the anterior column was definitely increased in size and the lateral column was slightly increased. These changes were not limited to the cervical region, but extended through the whole dorsal region. In the grey matter of the cord there was found to be marked atrophy of the nerve-cells. In many places these had entirely disappeared, and this destruction of cells was limited to the cervical enlargement of the cord.* In the latter case it seems probable that the condition of the ulnar nerve was due to chronic neuritis, such as has been described by various authors as occasionally occurring in the nerves leading to stumps.

The changes described by Drs. White and Edmunds, on the other hand, appear to be rather of an atrophic nature, the nerve-tissue wasting in the same manner as any other tissue may waste for want of proper use.

Dr. Reynolds's observations also establish the fact that atrophy of the nerve-fibres occurs in the nerves after amputation, and that the nerve-cells in the anterior horns decrease in number and in size, whilst those in the posterior horns also atrophy, though to a less extent.

* *Archiv. de Physiologie*, 1884, vol. iii. p. 430.

CHAPTER IV.

UNION BY FIRST INTENTION.

It has already been said that the usual result of nerve section is the degeneration of the entire peripheral end, and the question at once arises whether such a degeneration is inevitable. To obtain a satisfactory answer, both experiments and clinical experience must be considered; and as to the former, precedence must be given to Glück,* who made his observations on the sciatic nerves of the fowl and the pneumogastrics of the monkey.

According to this experimenter, the first change to be noticed after section is a retraction of the sheath and a spreading out of the myeline over the cut ends, which in a few days are found united by a grey translucent tissue. The further changes depend on the distance between the two ends. The removal of one or two centimetres of nerve prevents all regeneration, even after many months, if the ends are not brought together by artificial means. The nerves and muscles degenerate, the limb wastes, and the fowl dies about the fifth month.

If, however, the ends of the nerves are carefully sutured together, by preference with catgut, the results are quite different. The closer the approximation and coaptation of the two ends, the less is the amount of tissue formed about them, aptly called "nerve-callus," and the less is the degeneration below. The histological changes which have been found are the following. If a centimetre is removed and the ends left separated, the space between the two extremities is filled by a soft cellular granulation tissue containing vessels; the ends of the nerve undergo degeneration. One or two months later only a dense fibrous tissue is to be found in the interval, containing no nervous constituent. Glück did not in any case succeed in obtaining regeneration when a large piece of nerve was removed, but if there had been a simple section, and the ends were

* See Virchow's *Archiv*, 1878; *Lancet*, June 1, 1878; *Rev. des Sci. Med.*, 1881; Report of Surgical Congress at Berlin, 1880.

sutured, rapid reunion was obtained in such cases. In eight days the cut ends were united by naked axis cylinders, which were subsequently coated with myeline; the only sign of degeneration of the lower end was a slight multiplication of the nuclei for the first few days. This may fairly be called union by the first intention.

In a case where the section had been made without involving the perineurium the fowl walked easily in two days, and in other cases where complete section of the sciatic had been performed and the ends well sutured, function was restored in seventy hours.

Even in cases where a portion of nerve had been excised and the ends sutured, rapid union took place by means of the nuclei of the sheath, and with scarcely any fatty degeneration of the peripheral end.

In one case Glück removed a portion of the sciatic of a chicken three centimetres long, and replaced it by a similar piece taken from a rabbit. In eleven days sensation and muscular power were restored.

In the cases above quoted it must be noticed that the degeneration of the lower end is said to have been prevented by the suture. The author also insists on the wound closing by first intention.

If absolute proof be required of the reality of the union in these cases it can be supplied, for on the fourth day after division and suture of the sciatic in a fowl, mechanical or electrical stimuli applied to the nerve isolated on a piece of glass, resulted in a contraction of the muscles to which it was distributed. Again, the vagus in the rabbit was also successfully sutured, as was found by the fact that ten days after division of it on the right side a section of the left pneumogastric did not cause death. Resection of the previously divided nerve, in addition, was however fatal, thus proving that the union had been sufficient to keep the animal alive after the nerve on the right side had been divided.

I think that Glück's results must be taken as establishing the fact that union by primary intention can and does occur under favourable circumstances, in the fowl and rabbit. But we must be very careful in applying these results to man. The difference in the rapidity of union between the nerve divisions in the fowl and in the rabbit was very marked, and in man it might be much greater. The rate at which degeneration takes place in the peripheral end varies in different animals, as has been well pointed out by Mitchell,* who says: "In the frog it is most speedy in hot

* *Op. cit.*, p. 77.

weather, and in the hibernating animals Schiff states that it is so singularly slow that five weeks elapsed in the marmot, with less change than five days produced in the dog. In the snapping turtle (*Chelonia serpentina*) I found it to be equally tardy during the winter. Some years ago, in the autumn I cut the left sciatic nerve in two box turtles, which soon buried themselves in my garden. On their reappearance in April I found the nerves quite unchanged. Within the next month the peripheral end of the nerve underwent complete alteration."

However valuable, then, the experiments may be which prove the possibility of immediate union in the lower animals, it cannot be said that the proof holds equally good for man. But, in the lesions brought under the notice of the surgeon, the opportunity of establishing the reality of primary union of nerves by the microscope has not yet, to my knowledge, presented itself. We must therefore judge by the re-establishment of the *functions* of the divided trunk. And here a considerable difficulty offers itself, for many observers, notably Létievant, and Arloing and Tripier, have objected to the recurrence of *sensation* in the part supplied by the divided nerve as offering proof of its restoration, for they argue that the other nervous trunks take the place in part of that which is injured, and convey the sensations in question. But, as will subsequently be seen, these "sensibilité supplée" of Létievant are by no means so perfect as the sensations conducted by the normal nerve, at any rate for a considerable time after the section, if ever; and, moreover, though the surrounding muscles may more or less supply the part of those paralysed, the latter are themselves absolutely powerless, and rapidly degenerate and atrophy.

A rapid restoration of perfect sensation, together with an absence of wasting, and a reténction of the contractility of the muscles, may thus be taken as certain proof of the restoration of the continuity of the divided nerve.

The subject is one on which there has been much controversy, but I may say at once that, from clinical observations, I have no doubt of the possibility of primary union, although I think it is certainly very rare, and, in support of my opinions, will quote the following cases:—

H. H., aged twenty-three, was admitted into St. Bartholomew's Hospital on November 20, 1881. He had fallen with outstretched hands on to some sheets of loose glass a few minutes

before arriving at the hospital. On examination I found a large lacerated wound about an inch above the palmar surface of the right wrist, a flap of skin and muscle being turned downwards towards the palm of the hand. The whole of the flexor tendons of the wrist and fingers, except the flexor carpi ulnaris and the innermost tendon of the flexor sublimis digitorum, were divided. A small piece of bone was cut out of the radius, and the pronator quadratus was torn. The radial and interosseous arteries bled freely and were tied; the *arteria comes nervi mediani*, which was very large, was similarly treated. The median nerve had been divided in two places, and the intervening portion of it, nearly an inch in length, lay loose in the wound, and was accordingly removed. I then drew down and stretched the upper end as forcibly as possible, and sutured it to the lower portion with carbolized catgut, the cut surfaces being brought into contact with some difficulty after extreme flexion of the wrist. As many tendons as possible were similarly fixed, and the wound dressed with carbolized oil, the hand being steadied in a position of flexion by means of a splint.

Nov. 21st.—Much pain in the hand; no sensation whatever in the parts supplied by the median. Temperature 103° .

22nd.—The edges of the skin have sloughed, but the deeper parts look healthy.

Dec. 1st.—Sensation has been tested daily, but this morning, for the first time, he can tell which finger is pricked with a pin. No pain. A good deal of the wound has healed, and the part is granulating healthily.

3rd.—With his eyes blindfolded he can now tell with certainty which finger is touched with the handle of a pen; the prick of a pin causes pain.

7th.—Sensation in the thumb, index, and middle fingers is nearly perfect. He can feel the slightest touch, and can localize it accurately. Is fully sensitive to the prick of a pin, and can move the fingers slightly.

16th.—Has much improved in the power of flexion; can thoroughly oppose the thumb and pick up a pin; says he has still a slight sensation of numbness; the fingers are all quite warm and fully sensitive to all stimuli.

24th.—The wound has healed except for a very slight ulceration opposite the seat of injury to the radius; he says that, except for some stiffness in the fingers, one hand feels much the same as

the other. Has increased power of movement in the fingers and thumb.

Eight months later this patient came to show himself at the hospital. He could not quite bend the fingers into the palm, owing to the adhesions of the tendons to the scar; otherwise there was no difference between the two hands, and the man said he could work and feel as well with one as the other.

I am indebted to Mr. Menzies for the details of the following case, which appears to me to be of unusual interest, alike from the care with which it is recorded and the rapidity with which the functions of the injured nerve were restored.

Primary Suture of the Median Nerve, with Union by First Intention.—J. W., aged fifteen, was admitted to the West London Hospital on November 29, 1884, having fallen on a glass bottle and cut his wrist. On examination there was found to be an incised wound an inch and a half long on the anterior aspect of the right wrist. The tendon of the palmaris longus was seen to be severed. The median nerve was completely divided. There was hæmorrhage from the arteria comes nervi mediani, and the patient had complete anæsthesia over the part supplied by the median nerve. The ends of the nerve were exposed and sutured with three catgut stitches passing through the trunk itself.

Nov. 30th.—Patient had a good night, but complains of pain.

Dec. 1st.—Wound dressed. He has tactile sensation, and localizes accurately in the parts which were previously anæsthetic, with the exception of the last two phalanges of the index finger. The prick of a pin causes pain. He can distinguish the points of two pins one inch apart. Sense of temperature is uncertain, especially that of cold.

6th.—Wound healing by granulation. Sensation is fully established to all forms of stimuli. He can appreciate the points of two pins half an inch apart, except on the index finger.

8th.—Sensation returned in the index finger.

20th.—The wound has healed. Sensation is equal to that of the other hand for all stimuli.

Jan. 20th, 1885.—He uses the hand quite well; he says it is as good as it was before the injury.

July 20th, 1885.—The hand differs in no way from that of the

other side ; the muscles are quite natural, but they do not react to either faradism or galvanism.

As to the actual lesion, and the rapidity of the subsequent recovery in the first case, there can be no room for doubt, for the patient was seen both at the time of the accident and during his convalescence by many competent observers, and the conditions I have described were frequently verified. The case under the care of Mr. Menzies is, again, in my opinion, quite undoubtedly one in which primary union occurred. In no other way than by actual union of the previously divided fibres is it possible to explain the preservation of such perfect sense of touch, pain, and temperature, and above all of muscular power. As to the completeness and rapidity of the cure the patient himself bore the strongest testimony, insisting that his hand was not numbed for more than about a day, and that it was "quite as good as the other in three weeks," notwithstanding that there had been a considerable wound. In other cases that I have observed, there has been noticed a rapid restoration of function after primary suture of various nerves, leading one to believe that some fibres at least had undergone primary union ; but the cases already quoted are sufficient for my present purpose—namely, to establish the fact that "primary union" of recently divided nerves, without any antecedent degeneration, is quite possible in man. For although up to the present no case has been recorded in which a microscopic examination could be made of the nerve during the process of repair, yet the complete return of sensation and of motion is a sufficient proof of the reality of primary union. Supposing that in any given case primary union does not occur, the length of time required for the restoration of the continuity of the nerve-trunk is very variable. Paget considers that a year or more is requisite. Létiévant observed cases at the end of the nineteenth and fourteenth months respectively. The time required will necessarily depend on many circumstances. If the ends are far apart, if the wound sloughs, if a large quantity of dense cicatricial tissue intervenes, and if the cut nerve contracts adhesions to the surrounding muscles and tendons, union will be long delayed. In connection with this question the following two cases are of interest: the first being an example of failure of primary union, due probably to separation of the cut ends, followed by subsequent regeneration ; the second showing very plainly that, even when the best contact is main-

tained, primary union may be interfered with by erysipelas and sloughing.

Mary Ann P., aged nine years, was admitted into St. Bartholomew's Hospital in October 1879, having sustained a deep cut above the wrist-joint on the palmar surface. There was complete loss of sensation and motion in the parts supplied by the median nerve, but the cut ends could not be found. A few weeks later the patient was discharged unimproved and with some wasting of the muscles of the ball of the thumb.

On July 24, 1882, I had an opportunity of examining the hand, and found it in the following condition:—Scar neither painful nor tender. Hand well nourished and plump, not at all atrophied. Fingers straight; can bend them well, but does not make a very good fist. Movements of thumb quite normal. Sensation perfect. No trophic changes. Suffers slight pain in the hand in cold weather. Her mother says that feeling did not begin to return till a year after the child left the hospital, but that since then motion and sensation have steadily improved.

R. W., aged forty-four, was admitted into St. Bartholomew's Hospital on July 6, 1882, on account of a wound on the inner side of the upper arm, which divided the biceps and a part of the median nerve. As the divided portions of the nerve tended to separate from each other, catgut sutures were inserted and the ends drawn together; the muscle was treated in a similar manner.

On the 11th I found the wound suppurating, and the patient complaining of a sensation of numbness in all his fingers. The sensory condition was as follows:—Thumb: Tactile sensation impaired over the distal phalanx, both front and back; also sensations of pain and temperature; no place, however, is quite anæsthetic. Proximal phalanx normal. Index finger: No sensation of touch, pain, or temperature over the whole palmar surface, or the dorsal surface of the last phalanx and half the second. Middle finger: No sensation of touch or temperature, but firm pressure with a pin at the tip causes pain, the seat of which he cannot localize; this statement refers to the palmar surface, the back of the finger being in a similar condition to that of the index. The fourth and fifth fingers are normal, as are also the entire palm and back of the hand. The movements of all the fingers are unimpaired, but the power to oppose the thumb is very deficient.

On July 15th erysipelas of the arm supervened; there was no improvement in the nervous symptoms; no trophic disturbances. The erysipelas lasted some time, and no improvement was present until August 19th, at which time he was able to distinguish two points of a pair of compasses a quarter of an inch apart on the dorsal surface of the second phalanges, and could localize the touch of a pencil except at the tips of the fingers on the palmar surface. At the time I made this note I had not seen the patient for ten days, so am unable to fix the exact date at which sensation commenced to return.

A few days later the patient left the hospital, and did not show himself again till October 27th, when he exhibited the following condition: Forearm slightly wasted, and feels firm and hard; the range of supination is limited, apparently by the contraction of the pronator radii teres; movements of fingers good; ball of thumb much wasted. He has now no power of opposition, the movements of the thumb having deteriorated since he was last seen. Trophic: No other trophic disturbances, but the fingers are cold and blue. Sensation—Thumb: Tactile, thermic, and pain sensations all present, and but little, if at all, impaired. Index: Can localize well all over, but sensation is impaired at the tip; sensation of temperature good. Middle: In much the same condition as index, but the skin over the third phalanx is more anæsthetic. He was now ordered to be galvanized twice a week, and to employ friction to the whole forearm and hand, with a mixture of equal parts of lin. saponis and lin. camph., also to use the forearm as much as possible, and to keep it warm.

Dec. 8th.—Further improvement in both motion and sensation. Has returned to his work as a lamp-cleaner on the railway.

Aug. 9th, 1883.—Sensation quite perfect, except at the tips of the index and middle fingers. Even here it is scarcely at all impaired, merely amounting to a slight loss of acuteness. Still some wasting of thumb muscles, but he has fair voluntary power in them. No re-action to electricity. Nails, skin, &c., normal.

March 26th, 1884.—Sensation perfect. Muscles quite regenerated, being as large and strong as those of the other hand. All the muscles supplied by the median re-act to faradism, though as yet only feebly.

In the foregoing case it will be seen that although only part of

the nerve was divided and good apposition maintained, yet a year and nine months elapsed before function was completely restored, and there can be little doubt that this delay must be attributed to the erysipelas, which prevented healing by first intention. I may also take the present opportunity of expressing my very firm opinion that the commonly accepted doctrine that partial section or wound of a nerve-trunk is more dangerous, and more likely to lead to complications than complete section, is quite erroneous. I have no doubt at all that, on the other hand, the amount of trouble is directly proportionate to the amount of nerve-fibres divided, and have arrived at this conclusion after a clinical experience of many cases, both of partial and complete section.

The influence that the amount of nerve removed exercises on the length of time requisite for repair is well instanced by experiments on animals recorded by Létiévant. "After a simple section, the reunion of the ends by a cicatrix and the re-establishment of the functions requires three or four months, and this ought to be considered a good result. After resection of a centimetre, the same time is necessary. If more than a centimetre, five, six, twelve months, or more. After resection of more than three centimetres, the ends are only united by fibrous tissue, if at all."

Considering the favourable results obtained by Glück by suture of the two ends after resection of a portion of nerve and the rapid repair in one of the cases I have related above, it is most probable that it is the distance of the divided ends from each other rather than the actual loss of nerve that influences the time required for reunion.

That the cut ends of a divided nerve can unite, even after excision of a considerable portion, is sufficiently proved by the case I have already described. That partial reunion may occur when the ends are widely separated has been shown by Mitchell. Three such cases are recorded by this author and Bertolet in the *American Journal of Medical Science* for 1876. In the first, both the musculo-spiral and median nerves united after excision of about an inch of each. In the second, after removal of an inch of one of the digital nerves, complete union was found in eighteen months. In the third, the radial nerve was repaired within ten months of excision of two inches of its trunk.

But although the preceding cases may fairly be adduced in evidence of the contention that it is possible for union of nerve to occur after resection of portions of nerve-trunks, it would

be the gravest error to draw from such cases the conclusion that reunion occurs as a rule. And it is to be noticed that even in the instances above quoted the restoration of function was most imperfect. In very many cases, even of simple section, which are not treated, no union occurs in man—in far more, I think, than is generally believed; and I cannot agree with Mitchell that “the capacity of nerves to re-make their lost parts is almost invincible.”* The records of surgery tell a very different tale, and one which is, unfortunately, much more unfavourable for the sufferers from nerve injury. The conclusion that repair of nerves is inevitable has been drawn from a return of pain in cases of neuralgia which have been treated with temporary success by the operation of neurotomy or neurectomy. Such conclusions are not warranted. Pain may return, and so may sensation, independently of nerve regeneration. The real truth is to be found in a study of cases of accidental nerve section which have not been treated, and in such, even where no bulk of nerve has been excised, my own experience and that of many other surgeons is entirely opposed to the conclusion that nerves whose ends are separated show any irresistible tendency to unite. If they unite at all, they do so in a most imperfect manner, and frequently there is no sign of repair. Although, as I have already said, the lower end of the nerve undergoes regeneration even though separated from the proximal portion, it seems probable that, after union by first intention has failed, the bringing together of the divided ends materially hastens the regenerative processes. For, as will subsequently be shown, a suturing together of nerve ends, which have been separated four, five, or six months, is sometimes followed by a very immediate and rapid return of function; in other cases, however, the process is slower, and in some it fails. In the cases which succeed it is evident that the otherwise very tardy process of regeneration is considerably accelerated by a union of the nerve with its centres of nutrition; and this, indeed, is rather what might be expected. Some Continental surgeons and physiologists have been unable to reconcile the plain facts taught by the results of secondary nerve suture with their theories as to how the injured nerves ought to behave. They argue that because in a given case of secondary suture no nerve-fibres or axis cylinders can be found in the distal end at the time of operation, therefore any return of sensation which immediately or in the course of a few days follows operation and suture cannot

* *Erain*, vol. i.

be due to a re-establishment of the continuity of the injured trunk. Such objections as these will have no weight with any one who is not hopelessly wedded to theory, for the facts in many of the cases which I shall mention in speaking of "treatment" are too plain to need any further advocacy on my part, and to them I would refer for confirmation of the statement that suture of nerves after many months separation may, and frequently does, result in a rapid restoration of function through a restoration of continuity of the divided axis cylinders.

CHAPTER V.

TROPIC CHANGES CAUSED BY NERVE INJURY.

IN addition to the partial or entire loss of sensation and motion in the parts supplied by the divided nerve, the various tissues are liable to undergo changes which are chiefly of a degenerative nature, though sometimes combined with inflammatory conditions. The extent to which these changes are dependent on a want of nerve-force will be left for future consideration, and for the present it will be sufficient to study the morbid processes themselves. The first authors to draw attention to the altered nutrition of the parts supplied by a divided nerve were Hilton, in his *Lectures on Rest and Pain* (p. 199), and Paget, in the *Medical Times and Gazette* for March 1864; but since then they have widely occupied the interest of surgeons, and it would be impossible to allude here to all the writers on this subject, amongst whom the names of Charcot, Weir Mitchell, and Hutchinson occupy the foremost places.

It must first of all be premised that many of the changes to be described, and which will be known once for all as "trophic changes," are not by any means the invariable sequel of nerve section, but rather that, instead of such conditions being the rule, they are the exception.

The Skin.—The condition of the skin most characteristic of nerve lesion is a smooth shiny-red appearance, generally known by the name of "glossy skin." The description of Paget in the *Medical Times and Gazette*, already alluded to, yet remains the most graphic. He says: "In well-marked cases, the fingers which are affected (for this appearance may be confined to one or two of them) are usually tapering, smooth, hairless, almost void of wrinkles, glossy, pink or ruddy, or blotched as if with permanent chilblains. They are commonly also very painful, especially on motion, and pain often extends from them up the arm. In most of the cases this condition of the fingers is attended with very

distinct neuralgia, both in them and in the whole arm, and its relation to disturbances of the nervous condition of the part is, moreover, indicated by its occasional occurrence in cases where neuralgia continues after an attack of shingles affecting the arm. In two such cases I have seen this same condition of the fingers well-marked, and only very slowly subsiding, and seeming unaffected by the ordinary treatment of neuralgia."

Weir Mitchell,* while agreeing with Paget's description, also remarks that the epithelium is partially lost, and that the cutis is exposed in places, while the subcuticular tissues are wasted. The same author notes that, "where a single nerve, as the ulnar, had been attacked, the described state of the skin was seen only in its ultimate distribution; but in other instances of more extensive nerve injury the central palm suffered, or a single finger, or the pulps of all of them. In others, the palm or fingers were dotted with islets of thin, red and glossy skin. The dorsum of the hand, as a rule, was in that member the part least subject to the alteration, while the dorsum of the foot was in that region the part most liable to suffer. . . .

"The state of the skin to which I refer is never present without burning pain, and commonly the earlier presence of this form of neuralgia enables us to predict the coming of the skin disease. In no case did it become visible short of two weeks, but usually it preceded the healing of the wound, and not rarely was to be traced to an outbreak of inflammation involving the wound. The duration of the malady varied from a few weeks to years, but in all the cases I have been able to follow it has either been cured or gradually disappeared."

The foregoing descriptions mainly agree with my own observations. Mitchell's statement, however, that this glossy skin is "never present without burning pain," admits, I think, of some doubt, and I question if the same condition is not sometimes permanent, despite his opinion to the contrary. Both of these points are illustrated by the following case:—

W. H., aged forty-two, divided his median nerve two inches above the wrist, in August 1870. On July 19, 1882, I found the skin over the back and front of the two last phalanges of the index and middle fingers red, glazed, and tightly stretched, so that it could not be pinched up in the least; there was no appearance of any papillæ

* *Op. cit.*, p. 157.

or of hair; the fingers as a whole were very thin and tapering. He had no pain of any kind, except in very cold weather, when he said the affected parts caused a tingling sensation of pins and needles. In this man, then, the glossy skin had existed twelve years, and as the patient assured me it showed no sign of improvement, we may fairly conclude that the condition was likely to remain permanent.

In another case of an old man who had divided his ulnar nerve, ten years previously, the skin over the little finger and part of the ulnar side of the palm remained glossy, yet without pain, except, as in the previous case, in cold weather.

In addition to the glossy condition just described, the skin is liable to various forms of eruptions, which may or may not occur coincidently with the above affection. Of these, undoubtedly the most common form is a vesicular rash, sometimes presenting an appearance very similar to herpes, but frequently occurring as large bullæ, such as are seen in cases of pemphigus. As in the case of glossy skin, it is chiefly the parts at the extreme periphery of the nerve which are affected, and these in a most irregular manner; for instance, after division of the median nerve it is common to find any one of the three digits supplied by it the seat of a bulla, while the others are healthy. The earliest date after nerve section at which I have found the appearance of vesicles recorded is the second day; the case is detailed by Mr. T'Anson, in the *Medical Times and Gazette* for December 30, 1871. Mitchell saw the thumb rapidly covered on the fourth day by a large bulla, and "looking as if blistered." These eruptions are very common for some months after the primary lesion, but in cases where the section has occurred some years previously I have not found them, neither do I find mention of them by other writers under similar circumstances.

In addition to the vesicular eruptions, Mitchell describes an eczematous condition of the skin which he thinks is more frequently found than true herpes, and, indeed, it often becomes very difficult to give a name to a rash which is not quite like any that occurs under other circumstances.

In some cases the inflammation of the skin is more intense and results in the production of abscesses or ulcers. The former, which have been particularly described by Hutchinson under the name of "subcuticular whitlow," are most common, as their name

implies, at the tips of the fingers; the pus in them is only covered by the upper layers of the skin, and the nail is sometimes destroyed; the course of the whole inflammation is, however, painless. The ulcers which are found at the tips of the fingers are frequently the result of a subcuticular whitlow, which has burst, and thus exposed the delicate papillæ, which, being free from all tactile sense, are constantly liable to irritation by surrounding objects.

The ulcers thus formed sometimes proceed to the destruction of a considerable amount of tissue, and I have seen one case in which nearly the entire tip of the index finger and part of the middle were eroded in this manner within five months of the accident.

It must, however, be borne in mind that many of the ulcers which follow nerve section owe their primary origin to some traumatism, and more especially to the effect of heat or cold acting on an anæsthetic part. In one case that came under my notice, the man had burnt the end of his finger with a lighted pipe; in another, by carrying very hot plates; in a third, by touching one of the bars of a fireplace; and such instances could be indefinitely multiplied.

In many patients, as pointed out by various authors, the ulcers heal with great readiness, but such is not always the case, more especially, I am inclined to think, where no traumatic origin was present as an exciting cause. In the case above-mentioned of destruction of the tip of the index, the ulcer after healing again broke down, whilst the hand was completely protected from injury; and in another the ulceration was still present and slow to heal ten months after the division of the nerve.

In a few rare cases a whole finger, or fingers, may become completely gangrenous. Hilton describes such a case, in his work on *Rest and Pain*, in which the two last phalanges of the fifth and the tip of the fourth finger were completely separated by a line of demarcation. The cause of this was an exostosis pressing on the ulnar nerve in the subclavian triangle, and also causing occlusion of the subclavian artery. There can be no doubt that this plugging of the vessel would act as a predisposing cause, but, as Hilton justly points out, the whole of the hand was subjected to the same influence, though only those fingers supplied by the ulnar nerve suffered.

A less equivocal case is that recorded by Mr. T'Anson, already alluded to. Here the median nerve was divided at the wrist, in a

FIG. 12.

A hand, showing ulceration of the tip of the index-finger and necrosis of the ungual phalanx following an injury to the median nerve at the wrist.



Fig. 12.

man aged twenty-four, on June 8. Two days later, vesicles and black patches appeared on the fingers, but improved under galvanism. On August 11, bullæ again appeared, and were followed by gangrene of the whole index finger.

Gangrene following Injury of the Ulnar Nerve.—

In the following case gangrene of a part of the hand followed on division of the ulnar nerve.*

On November 29, 1881, W. P., aged forty-seven, received a severe lacerated wound from a circular saw on the inner side of the forearm, dividing, together with other structures, the ulnar artery and nerve. The artery was tied, and the wound was dressed with carbolized oil. The wound healed by December 24. The patient was then discharged as cured, but returned on January 6, 1882, with gangrene of the ulnar side of the hand, extending into the little finger. The whole hand was œdematous. Finally a slough, about "half an inch deep," came away, and the gangrene ceased to extend.

The *nails and hair*, as might be expected, share in the changes affecting the skin. While speaking of subcuticular whitlow, I have mentioned that the nail of the affected finger sometimes perishes, but the nails occasionally undergo other changes in shape and texture of a kind peculiar to nervous lesions.

Judging from a considerable number of cases of such injuries that have come under my own notice, I should be inclined to consider characteristic changes in the nails as not very rare, although this opinion is not supported by the almost complete absence of any mention of such diseased nails by other authors. Thus, of seven cases recorded by Hutchinson of divided nerves, in only one were the nails found to be "stumpy, broken, and uneven on the surface," while other English surgeons have passed over the question in silence.

Mitchell, Morehouse and Keen, however, in some patients noticed very considerable lesions. They say: "The alteration in the nail consists of a curve in its long axis, an extreme lateral arching, and sometimes a thickening of the cutis beneath its extremity. In other cases a change takes place which is quite peculiar, and which to us, at least, was new. The skin at that end of the nail next to the third finger-joint becomes retracted, leaving the sensitive

* Root, *N.Y. Med. Record*, 1882, p. 560.

matrix partly exposed. At the same time the upper line of union of skin and nail retreats into, or under, the latter part, and in place of a smooth edge is seen through the nail as a ragged and notched border. The patient who presented these changes in the most striking form had also lateral arching of the nail, but no longitudinal curving. It was a case of most terrible suffering from a combination of burning pain in the hand and neuralgic pain in the forearm.

"No deformity of nails in tubercle at all approaches that which nerve-wounds occasion. Indeed, we think it would be possible for one familiar with these cases to diagnose the existence of a nerve lesion from the form of these protuberant and oddly curved nails.

"When the nails of the toes have been attacked, and they are very rarely so, the curving is less marked, but a distressing ulceration is apt to occur at their angles, and to break out again and again, despite of every care and attention.

"In many cases of nerve-wounds, where there is only ordinary neuralgia, and not glossy skin and causalgia, I have seen the nails clubbed in some places, and in others dry, scaly, cracked, and fragile; occasionally they are very thin, so as to be tender—atrophied, in fact . . . even complete nerve section does not prevent lost nails from being re-formed."

In the above graphic description, however, the authors do not mention in what proportion of cases they observed such lesions, or whether they occurred, as a rule, in recent divisions or in those of later date.

It has appeared to me that after nerve section there may be simply a diminution of the rapidity of growth of the nail, combined with a stunted and fibrous appearance; or else that changes of a more special nature, such as those described above, may be observed.

Of eleven cases of old injury which I examined consecutively, in only one was there any stunted and fibrous appearance of the nails; none of the other ten patients exhibited any morbid changes whatever, and for the most part expressed their opinions that the nails of the one hand grew as rapidly as did those of the other. In ten consecutive cases of more recent nerve section, within a year of the accident, eight patients showed no change in the nails; but in the two others the latter presented a very strange and characteristic appearance, in many respects resembling the description by Mitchell.



Fig. 13.

FIG. 13.

A hand five months after division of the median nerve. The nails of all the fingers and of the thumb are excessively curved, fibrous, and ridged.

The first patient was a boy, aged fourteen, who had sustained a division of the median and ulnar nerves nearly a year previously. The nails of all the fingers were short, stumpy, and broken, excessively arched both longitudinally and transversely, with transverse furrows and ridges running across them, the latter being marked with a delicate longitudinal striation, giving them a "toothed" appearance. The nails were thick and not tender, and the surrounding skin was not retracted from their bases. The patient said that they had been in this condition ever since a few weeks after the accident; he thought they grew as rapidly as those on the opposite hand.

The second patient was a lad, aged seventeen, who had divided the median nerve five months previously, and in whom partial union had resulted and was still progressing. The nails of *all* the fingers and of the thumb presented conditions very similar to those just described, except that they were very long, a condition combined with their extreme curvature, which gave them a talon-like appearance. In this respect the thumb-nail differed from its fellows, being short and only half-grown; this was accounted for by the fact that the nail had been painlessly shed from this digit a month previously. The patient was certain that all the nails grew rapidly, and their appearance certainly warranted the statement.

These cases support the belief that trophic changes in the nails appear soon after the nerve injury, as might be expected from the time at which similar lesions are found in other parts. In addition to the curvature, the most characteristic appearance was found in the peculiar striated or toothed condition of the transverse ridges, which was quite different to anything I had ever seen, and which is well shown in the accompanying drawings. In the last patient, perhaps the most surprising fact was that, although it was quite certain that only the median nerve had been divided, yet the nails on the fourth and fifth fingers were quite as much affected as those of other digits. This peculiarity I have since seen in other cases.

In a few instances I have found the nails exceedingly smooth, shiny, and vitreous.

Changes in the hair growing in parts deprived of their nerve-supply have appeared to me to be very common.

In most of the cases I have examined, the hair, when any has been present, has appeared short, stumpy, and brittle. In some

patients it was altogether absent, and Paget and Weir Mitchell have observed that this is especially the case in patients with glossy skin. In one case I have been enabled to examine a portion of such skin microscopically. I found the cutis much diminished in thickness, and the epidermis smoothly stretched over it with an almost complete absence of papillæ, such as may be seen in scar tissue. Such of the hair follicles as remained were shrunken and ill-developed, and the sebaceous and sweat glands were in a similar condition.

In some rare exceptions the growth of hair after nerve-wounds has been very excessive. Mitchell quotes several examples, but does not appear to have seen cases himself, and none have come under my own notice.

Hamilton, however,* records a case in which a nerve appears to have been wounded in the operation of venesection, and in which symptoms of chronic neuritis ensued, the arm being subsequently covered by a rich growth of hair; the patient was a young lady.

The *connective tissues* deprived of their nerve-supply usually undergo atrophy. In some patients, however, there is developed a great tendency to œdema, a condition which is probably due to section of some of the vaso-motor nerves. Mitchell has described, in addition, cases where hypertrophy of the connective tissues was very marked, and was apparently the result of chronic œdema.

The *secretion of sweat* is in most cases more or less affected. By most of the patients I have seen, in whom the injury was of some standing, there was a tolerable certainty expressed that the parts deprived of their nerve-supply were always dry. I examined some of them on very hot summer days, and in most of them the parts affected remained dry, while the rest of the hand was moist, and this despite energetic friction. In some cases, apparently those of partial division complicated by neuritis, the secretion of sweat has been described as excessive, and Mitchell records cases in which it was very acid and foul-smelling.

Considering these facts by the light of recent researches in physiology, it might almost be said that such conditions would be only just what we might expect from nerve section or irritation; but it is interesting to note that they were observed before experiments had proved the dependence of the secretion on nerve-supply.

The *temperature* of the paralysed parts often differs consider-

* *Dublin Journal of Medical Science*, 1830.

FIG. 14.

A hand seven months after section of the median nerve. The nails of all the fingers and of the thumb are divided by transverse ridges which separate the portions of the old nails from the newer portions which have grown since the accident. The new nails are fibrous and ridged. The case is fully recorded on page 134.



Fig. 14.

ably from that of the opposite side of the body, of contiguous digits, &c. Immediately after section of a nerve—*e.g.*, the median—the distal parts become suffused with blood, and appreciably hotter to the touch. Waller and Mitchell have both shown that a similar rise of temperature follows on compressing the ulnar at the elbow, and the latter observer has also demonstrated that this elevation does not occur if a tourniquet has previously been placed on the brachial artery,* thus showing the dependence on the vaso-motor system.

This increased heat is well instanced in the two following cases :

A man, aged thirty, divided his ulnar nerve on May 8, 1885, and came at once to St. Bartholomew's Hospital, where the cut ends were sutured by the house-surgeon, Mr. Murray.

Eight hours after the accident the temperature, taken between the fourth and fifth fingers, was $100^{\circ}.2$; between the first and second, 99° .

May 10	Between 4th and 5th	99° F.	Between 1st and 2nd	98° F.
„ 11	„ „	$99^{\circ}.6$	„ „	$98^{\circ}.2$
„ 14	„ „	98°	„ „	$97^{\circ}.4$
„ 15	„ „	$98^{\circ}.2$	„ „	$98^{\circ}.2$
„ 16	„ „	$101^{\circ}.6$	„ „	$101^{\circ}.6$
„ 18	„ „	$100^{\circ}.6$	„ „	$99^{\circ}.6$
„ 19	„ „	$99^{\circ}.4$	„ „	$98^{\circ}.8$
„ 20	„ „	98°	„ „	$97^{\circ}.6$
„ 21	„ „	99°	„ „	98°

Speaking generally, the temperature of the paralysed fingers averaged about 1° higher than that of the others, and this variation remained constant, despite alterations in the general body temperature.

In the next case a woman, aged twenty-seven, divided her median nerve at the wrist.

The next day the temperature between the index and middle fingers was 99° , whilst that between the ring and little finger was $96^{\circ}.6$. The day afterwards the temperature between the index and middle finger was $98^{\circ}.8$, that between the ring and little finger, 97° .

The following case, by Richelot,† is another instance of the rise

* *Archiv. of Sci. and Prac. Med.*, New York, 1873.

† *Bull. et Mém. de la Soc. de Clin. de Paris*, 1883, p. 438.

of temperature that may follow on separation of peripheral parts from the nervous centres :

Fracture of Humerus, followed by Neuroma of Median Nerve.—Resection of Nerve followed by Rise of Temperature in Hand.—A man, aged twenty-six, was admitted to the Hospital of La Pitié on December 30, 1882, on account of severe pain in the right forearm. His history was that at the age of seven years he had sustained a compound fracture of the lower end of the right humerus, that the arm had always been in a weak condition, and the elbow had been stiff.

On admission there was found to be on a level with the site of fracture a small oval swelling, the size of an almond, situated apparently on the median nerve. Pressure on this swelling caused pain referred to the thumb, index and middle fingers. In these fingers also sensation was much impaired. The muscles of the forearm and of the ball of the thumb were much wasted, but were not completely paralysed.

The temperature of the hand on the affected side was $4^{\circ}.5$ Réaumur below that on the opposite side.

On January 15, 1883, M. Verneuil removed the tumour by operation, completely cutting out the portion of median nerve from which it grew, and not stitching the cut ends, but leaving them widely separated. The tumour itself was found to be a fibroma, separating the nerve-tubules, and by its pressure destroying some of the nerve bundles.

After the operation the temperature of the hand on the side on which the operation had been performed—*i.e.*, the right—was 34° C., of the left, 30° C. The day after, temperature of right was 35° C.; of left, 25° C. Sensation was still further lost, but was *nowhere entirely absent*.

The further history of the patient is not given.

But although immediately after injury and for a varying number of days there is an increase of temperature in the peripheral parts supplied by the damaged nerve, yet in the course of a few weeks, more or less, there is a decided fall of temperature, so that in by far the larger number of old nerve-wounds the peripheral parts are cold and livid.

The amount of loss of heat varies much. In one of Hutchinson's cases it was as much as 16° compared with the finger of the opposite side; in two others 10° ; and, indeed, it may vary

between these and the normal temperature in a manner which admits of no rule being formulated.

In a case brought before the Pathological Society* the gradual restoration of heat, coinciding, apparently, with nerve repair, is well instanced. The patient was a boy, aged six and a half years, who suffered division of his ulnar nerve in August 1861. In October of the same year the temperature of the fingers supplied by it was 10° Fah. lower than that of the others which derived their supply from the median and radial. On November 28 the difference was 5° . In July 1862, 5° . In November 1865 there was only a difference of half a degree, and the muscles had resumed their normal bulk.

Sometimes, however, instead of any loss being discoverable, there is a distinct increase of heat; and Mitchell found the temperature raised one or two degrees in cases of "causalgia." These cases seem comparable with those of increased sweating.

The *muscles* in connection with a divided nerve undergo a rapid atrophy and degeneration, of a character which is completely different to the simple decrease in size which follows merely upon disuse. The final result of this process is a transformation of the muscles into a mass of fibrous tissue, firm and dense, neither contractile nor elastic, and sometimes mingled with a little fat. For some time after the nerve lesion, the muscle feels limp and flabby, the patient can exercise no control over it, and the tendon into which it is inserted no longer stands in relief under the skin—the muscle has in fact lost tone. This condition is gradually followed by wasting in bulk, and frequently by shortening of the muscle in its long axis.

Vulpian describes a reduction in the diameter of the primitive muscle bundles, with granulo-fatty changes, and complete disappearance of certain fibres. "In the early stage of alteration, the primitive fibres appear to be segmented, the muscular substance persisting in some places and being absent in others. At the same time we observe the formation of a more or less considerable quantity of fat vesicles in the connective tissue which separates the secondary bundles of fibres, and much more rarely between the primitive fibres."

Multiplication of the nuclei of the connective tissue of the muscle are also observed, while the vessels suffer only a loss of calibre, without other changes.

* See vol. xvii. of their *Transactions*.

The faradic and galvanic excitability of the muscles is soon lost; but at present I shall not further allude to the changes in the electrical reactions, as I propose to treat of them at greater length in the chapter on Symptoms of Nerve Injuries.

The trophic changes in the *joints* and *bones* next claim attention.

With regard to the joints, the description by Weir Mitchell must again be given the foremost place, for he was the first to describe the condition to which I am about to allude.* He states that the arthritic lesions may appear either early after the nerve lesion, or else at a later period, when the more immediate symptoms are subsiding. Under the latter conditions, "we may then have one articulation—and if only one, a large one—involved; or perhaps all the joints of a finger, or every joint of a hand, or of the entire limb, may suffer. The swelling is never very great, the redness usually slight, and the tenderness on touch or motion exquisite."

"This condition of things remains with little change during weeks or months, and then slowly declines, leaving the joints stiff, enlarged, and somewhat sensitive, especially as to movement. A small proportion of such cases find ready relief; but in many of them the resultant ankylosis proves utterly unconquerable, so that it is vain to try to restore mobility by manipulation or splints."

Such is Mitchell's account, and I make no doubt that cases such as he has described have been seen by him, yet it would be quite a mistake to consider that such are at all common. It has been my fortune to observe for some years past, and to keep constantly under my notice, a large number of cases of nerve injury of very various kinds, yet in none of them have I seen any joint affection so extremely acute and painful as those described by Mitchell.

On the other hand, I think that arthritic lesions of a less severe and more chronic kind are amongst the most common results of nerve injury. I have seen them over and over again, and for my own part am inclined to consider them as an almost invariable sequel of nerve lesion. It is difficult to understand how they have been missed by other observers; I suppose because they have not been looked for.

From my own observations, I should say that within a time

* *Op. cit.*, p. 169.



SOME TROPHIC LESIONS FOLLOWING INJURIES OF NERVES.

PLATE 3.

A hand, showing trophic changes in the nails and swollen ankylosed joints after injury to the median nerve at the wrist. The case is recorded on page 53.

Page 53.

varying from one to six weeks after injury to a nerve, the joints will usually be found somewhat stiff. The finger-joints have seemed to me to be much more liable to be affected than those of the wrist and elbow, and this not only in cases of injury inflicted low down in the forearm, but also where the wound has been in the upper arm.

Usually, but not always, this stiffness has supervened without causing the patient any pain, and, from the fact that the affected parts are often both anæsthetic and partially paralysed, the stiffening of the articulation not infrequently escapes the notice of the patient himself. In other cases, I have seen the joints swollen, painful, and tender. For several weeks the stiffness increases, and the movements of the joints, both active and passive, gradually diminish. Finally, there appears to be a tolerably firm fibrous ankylosis. The future of the case depends to a great extent on the condition of the injured nerve, and on the patient himself, for if the hand be not used, the stiffness is likely to be much more persistent than if resolute attempts are made to overcome the fixation of the articulations. If the divided nerve resumes its functions, the joints are much more likely to again become movable than in cases where no reunion occurs. In many cases they entirely recover, but in others, in spite of all treatment, permanent stiffness results. There is much in the condition of these joints which is suggestive of chronic rheumatism.

It is but rarely that an opportunity is afforded for an examination of the diseased articulation, and I am only aware of one case in which the results of such an examination have been recorded. The case I allude to is one by Blum,* in which the joints of a man whose median nerve had been divided several years previously were examined after death. The cartilages were thinned and softer than natural, and there was some cell proliferation. The articular bone also was rarefied.

In 1882, I had the opportunity of dissecting the hand of a man whose median nerve had been injured about eighteen months previously.

An examination of the hand after removal showed that the median nerve had been wounded above the wrist-joint, and that a fragment of wood was still buried in its substance. The finger-joints were one and all much stiffened. On opening those of the middle finger, the capsules were found to be thickened, and the

* *Thèse d'agrégation.*

cartilaginous surfaces of the most distal joint united by fibrous tissue. The terminal joint of the ring-finger was firmly ankylosed, the union being by *bone*, and so firm as only to yield to cutting instruments.

Microscopically examined, the cartilages were all thinned, and their normal hyaline matrix replaced in part by fibrous tissue.

With regard to the *bones*, I have not myself met with any case in which definite change could be assigned as the result of nerve injury. Instances have, however, been detailed by Blum,* Ogle, and Arnozan.† In the cases collected by these authors the chief alteration appears to have been a simple atrophy of the osseous tissue, such as might not improbably result from mere disuse. Thus, shortening of the femur is mentioned as a result of injury to the sciatic during childhood. In one of Ogle's cases, however, there was not only thinning of the bones of the hand in a case of section of the median nerve, but also bony union between the radius and ulna at their lower ends. Considering the paucity of information on the subject of bone lesions due to nerve injury, I think it may be concluded that they are of comparatively rare occurrence.

Such is a brief account of the various trophic changes that may follow on nerve injury. Instances of them are sufficiently numerous to allow most surgeons to become more or less acquainted with the more common of them, and although I might quote in detail numerous cases in support of the above descriptions, it is needless to enumerate them here.

What is of more importance is to inquire into the manner in which section of a nerve-trunk so affects the tissues to which it is distributed; and on this point opinions are much at variance.

The following are the chief theories:—

1st. That the changes are due to section of vaso-motor nerves, and consequent irregularity of the blood-supply.

2nd. That they are due to disuse of the paralysed parts.

3rd. That they are due to irritation of the centrifugal fibres set up by the injury.

4th. That they are due to the removal of a special influence exercised by the nerves on the nutrition of the tissues.

The first of these theories has been very extensively supported, but may, I think, be disproved. The arguments adduced in its

* *Loc. cit.*

† *Des lésions trophiques consécutives aux Maladies du Système Nerveux.*

favour have been mainly founded upon incorrect views of the vaso-motor system, and conclusions have been incorrectly drawn.

It is well known that section of the vaso-motor fibres results in the congestion and rise in temperature of the part to which they are supplied, and it has been rather hastily assumed that these changes may readily overstep their bounds and pass on to inflammation and destruction of the affected tissues. These conclusions were drawn on the supposition that the vessels of the part remained permanently in a state of suffusion. Such is not the case. It has been definitely proved that the vessels of any part are not entirely dependent on their connection with the medulla oblongata for their nerve-supply, but that local vaso-motor centres are present, which are capable of regulating the calibre of the vessels after section of all nerves connecting the latter with the brain and spinal cord.

The ear of a rabbit in which the cervical sympathetic has been divided will gradually return to its normal condition, and the former rhythmical contractions of the blood-vessels may again be perceived. The temperature also gradually approximates to that on the opposite side, and subsequently the ear or else the limb of a vertebrate animal, which, after section of the main nerve was markedly hotter than its fellow, will gradually become colder by several degrees. It will thus be seen that while the trophic changes may last an indefinite period, the condition which is supposed to give rise to them gradually passes away.

Again, while the vessels are turgid and swollen, the ear of the rabbit does not atrophy or inflame. On the contrary, the hair grows more luxuriantly (exactly the reverse of that on an extremity whose main nerve is divided), and the nutrition of the whole part is improved.

So much, then, for the experimental evidence ; but that afforded by pathology is none the less clear in its refutation of the claims made for the influence of the vaso-motor nerves on nutrition.

If it can be shown that in certain cases vaso-motor paralysis exists without trophic lesions, the independence of these two conditions might be considered demonstrated.

Now the first of these conditions is undoubtedly present in a large number of cases of infantile paralysis. It has been shown of late years that the seat of the lesion causing this disease lies in the anterior horns of the grey matter of the cord, and most probably in the ganglion cells which are found in this situation.

Further, it is well known that many of the vaso-motor nerves leave the spinal medulla by the anterior roots as low down as the eleventh dorsal.

These nerves, then, are *à priori* likely to be affected by the lesion in the cord, and it is a matter of clinical observation that the skin over the paralysed muscles is generally congested and its temperature raised, although later on it becomes cold and blue.

But infantile paralysis is never accompanied by changes in the nutrition of the skin, always excepting chilblains; there are no subcuticular whitlows, no herpetic eruptions, no loss of hair, and no glossy fingers. Yet, were these lesions dependent on loss of a proper vaso-motor supply, we might fairly expect to find them present in at any rate a certain proportion of these cases, whereas they are conspicuous by their absence.

And, on the other hand, we have the testimony of the best authors to prove that trophic changes may be present and the vaso-motor supply still intact. On this point Mitchell* writes: "If the vaso-motor nerves were alone responsible for the existence of all the lesions which follow nerve-wounds, it would be reasonable to expect always to meet with some rise or fall in temperature. Such, however, is not the case, and I have frequently met with profound trophic changes unattended by thermal perturbations, and the same remark has been made by other neuro-pathologists."

With regard to the second theory, that the wasting and degeneration are due to disuse of the part, it will be well to turn to the case of the muscles, and the claims made for this explanation may be readily set aside.

The most distinctive characters of the atrophy following division of a motor nerve are the rapidity of the onset and progress, and the fact that it is accompanied by "degeneration" of the muscle-fibres, so that the affected muscle will not react to faradism, but will readily do so to galvanism.

Now, on the other hand, we have innumerable cases of injury to the spinal cord, of hemiplegia and paraplegia, in which, so long as no destructive disease is in progress in the cord below the seat of the lesion, the paralysed muscles maintain very nearly their normal bulk, and do *not* give the *degenerative* reactions to electrical stimuli; yet these muscles are equally as powerless as those whose motor nerve is divided, so that were the atrophy due to simple

* *Op. cit.*

disuse, it ought to accompany the one lesion as frequently as it does the other.

Both the third and fourth theories involve the belief in the presence of a direct nervous influence over the process of nutrition, and may be considered together.

From an anatomical point of view, the distribution of the terminal nervous filaments to the cells themselves of the different glands, to muscle and connective-tissue fibres, &c., would render it extremely probable that they were intimately concerned both with their functional and vital powers, and experiment lends proof to this supposition.

If the fifth nerve of a rabbit be divided within the skull, the section is followed in about twenty-four hours by a cloudiness of the cornea, and subsequently by a destructive inflammation of the eyeball, and frequently by ulceration of the mucous membrane of the lips, gums and nose. Considering that division of the fifth necessitates an anæsthetic condition of the corresponding side of the face and of the parts involved in the inflammatory process, it seemed at first quite probable that the destructive changes occurring in the eye were the result of an inability to perceive and remove any irritating substances which might be lodged upon it. Snellen accordingly re-investigated the subject, and expressed his belief that with due care in protecting the eyeball, the subsequent inflammation might be avoided. His results have not, however, been obtained by others, and more recent investigations by Merkel have placed the matter in a rather plainer light. This observer states that the fibres, division of which causes the inflammatory conditions above described, are collected together in a small bundle on the inner side of the fifth nerve. If they alone be divided, while the rest of the nerve is intact, sensation of the corresponding side of the face is not lost, but destructive changes occur as before; and, on the other hand, if this bundle be left whilst the rest of the nerve is divided, no trophic troubles follow, though anæsthesia of the face ensues. It is therefore assumed that the small tract of fibres alluded to are essentially "trophic."

The numerous experiments bearing on the secretion of saliva by the submaxillary gland also tend to prove the reality of the trophic influence of nerves. When all of those supplied to the above-mentioned gland are divided, and a so-called "paralytic" secretion is set up, the gland-tissue ultimately degenerates. This degeneration is not due to cessation of function, for the gland continues to

secrete so long as it is able, and it may also be proved that secretion (which is but a variety of nutrition) may be started by stimulation of the nerve going to the gland under the most varied conditions of blood-supply, or even in its entire absence. It therefore appears that in the presence of a copious blood-supply and of a continuance of the functional activity, division of the nerves will yet cause an atrophy of the gland structure, while the presence of the nerves alone is sufficient for the maintenance of the salivary secretion.

The argument that the lesions of the skin are due to physical causes, such as pressure, heat, &c., applied to an anæsthetic part, cannot be maintained in its entirety. I have already stated that in some of the cases which have come under my own notice, some external injury has been the starting-point of an ulcer or inflammation of the finger; but this is not the case in all, and does not indeed apply to many of the trophic changes, such as loss of hair, herpetic eruptions, and others that might be mentioned. Again, in these cases, lesions occur while the patient is under observation, and frequently while the extremity is bound up in bandages, &c., which obviate all external influences. Lastly, ulcers, whitlows, &c., are more particularly prone to make their appearance very early after the date of the nerve injury, whilst the anæsthetic condition of the skin to which they are supposed to be due is much more permanent, and indeed exists under conditions such as manual labour, &c., which might fairly be expected to predispose to inflammatory conditions in a part insensible to pain. Yet as the anæsthetic condition outlasts the tendency to trophic change, the latter can scarcely be said to be dependent on the former. Many of these arguments have already been used by Dr. Poore, in the *Lancet* for May 19, 1887, and to his paper I am much indebted for many suggestions.

Against the theory of the trophic influence of nerves, it has been argued that the nutrition of some tissues—*e.g.*, cartilage and fat, whose nerve-supply is either very scanty or entirely absent—is independent of neurotic influence. Such is by no means necessarily the case, and indeed the changes which occur in the above-mentioned tissues after nerve section argue the contrary. Further, it is no argument to say that because any tissue maintains its nutrition, although unconnected with the nervous centres, therefore those which are supplied by nerves are independent of them. It is only fair to suppose that the more highly developed

a structure, the more dependent it is on the accurate working of every component part.

All other theories failing, we are then again driven back to the conclusion that the nerves exercise a distinct trophic influence over the tissues. Where, then, is this influence generated, and what are the conditions essential for its integrity?

These questions may be briefly answered by stating that so long as any tissue is connected to a healthy nerve-centre by healthy nerve-fibres, its normal nutrition is preserved. Each tissue, then, has its own centre of nutrition in the ganglion cells from which its nerve-fibre springs, the tissue, the fibre, and the cell being considered, as Dr. Poore puts it, to be one nutritive unit. One question which offers itself for solution is whether the ganglion on the posterior root acts as a centre for nutritive functions; but the answer must be that, though it may do so, yet *all* the trophic impulses are certainly not generated in it, as is proved by the fact that many of them follow lesions of the cells in the cord itself. But it may be considered necessary to still further localize the situation of the trophic cells of each fibre, and it only remains to be shown that the latter are not situated higher up the cord than the point at which each of the nerves takes its origin.

Simple section of the spinal cord, however, above the point of junction of any particular nerve-root, does not in any way interfere with the nutrition of the parts to which the same is distributed; whilst, on the other hand, any lesion involving the nerve-cells from which the fibres take their origin, results in trophic changes in the peripheral tissues. And MM. Déjérine and Lélouir, in the *Archives de Physiologie* for 1881, have demonstrated that in cases of acute decubitus the nerves themselves had undergone a degeneration, thus placing the tissues to which they were distributed in a condition similar to that which results from nerve section.

Again, in infantile paralysis, a disease in which the cells of the anterior cornu undergo destructive changes, atrophy of the muscles is the most marked symptom; and there is no doubt that the nerve-fibres also degenerate, for transverse sections of them show an increase in the connective tissue and a corresponding diminution of nerve-fibres, those which remain being in a perfectly healthy state. This condition is probably due to a degeneration of the motor nerves, their atrophied remains being seen amongst the normal sensory fibres.

But, granting that the nerves exercise a special control over nutrition, the nerve injury may be supposed to affect the latter in one of two ways: (1) By irritation of the trophic fibres; (2) By cutting off the permanent trophic influence which is constantly passing. Professor Charcot is the most notable supporter of the first view; others who formerly held to it, foremost of whom is Dr. Weir Mitchell, having given their adhesion to the latter explanation. In this particular Charcot follows the teaching of Samuel, who thus states his opinion. He says: "The sudden increase in the action of the trophic nerves beyond their ordinary physiological action occasions a rapid development of all nutritive processes throughout the parts to which they are distributed. Acute irritation of these nerves gives birth to a series of abnormal products, simply because it stimulates to the highest degree the nutritive processes. The tissues suddenly tumefy, the cells increase rapidly, they divide and multiply, and hence the formation of new structures which no longer resemble the parent one. We are accustomed to name this *tout ensemble* of phenomena inflammation."

Under this belief, Charcot states his opinion that muscular atrophy occurs most frequently "after contusions, punctures, and incomplete sections of the nerves—that is to say, after traumatic causes which are most able to produce neuritis, or at any rate neuralgia;" and this is also his opinion as regards other trophic lesions following nerve injury.

But this theory is not borne out by facts, and I have no hesitation in saying that in by far the larger number of cases of nerve injuries which I have examined, and which have shown trophic lesions more or less marked, the section has been complete, and there has been no reason whatever to suspect any neuritis or neuralgia. Moreover, in the greater number of cases described by other writers, similar conditions have existed. This explanation of Samuel's, then, is theoretical, but even on a theoretical ground it falls through. For, as Vulpian has pointed out, the nerve-fibres below the seat of section or other injury rapidly degenerate; how, then, can they convey the necessary irritative impulses?

I think, therefore, that it may safely be assumed that nerves do exist which exert a direct trophic influence upon the tissues, and that the currents which convey the same are constantly passing. The only question that remains to be considered is, whether the

existence of special nerve-fibres is necessary for the conveyance of trophic impulses, or whether the ordinary sensory and motor tracts suffice. It has been shown that there is nothing incongruous in the idea that any given nerve-fibre can convey currents either centripetally or centrifugally, so that there is no ostensible reason why the nerves of motion and sensation should not be amply sufficient for the purpose. And considering that trophic disturbances very rarely, if ever, occur without some interference with the sensory and motor functions, there is strong probability that the same fibres are capable of conveying the different impulses which are generated in the centres. This point, however, requires further investigation.

CHAPTER VI.

SYMPTOMS OF NERVE INJURIES.

Symptoms of Complete Section of a Nerve Trunk.—

The symptoms of nerve injuries of all kinds have much in common, but considering that those caused by bruising, pressure, partial division, &c., possess some points of difference from cases of simple division, I shall at present treat of the latter alone.

The *pain* caused by division of a nerve-trunk does not appear to be very severe, for, judging by the accounts of patients, no further pain than that caused by the skin wound seems to attract attention in, at any rate, the larger number of cases. Numbness and tingling frequently cause more anxiety than does the actual pain.

The *shock* following on an injury to a nerve-trunk is not a very noticeable feature in patients met with in civil practice, though Mitchell records many cases of gunshot wounds in which it was present.

The *loss of muscular power* and of the *sense of touch* are symptoms of far greater import than either of the foregoing. With regard to the former, it may be said at once that the muscles supplied by the divided nerve become absolutely powerless, and remain so as long as the divided nerve-ends continue ununited; their functions may be to a certain extent supplied by surrounding muscles, as insisted on by Létiévant, but they themselves undergo a rapid atrophy and degeneration, which is the cause of many deformities, and which affords a sure evidence of the injury that has been sustained.

Sensation may be affected in many ways; there may be loss of sense, of touch, of temperature, anæsthesia, hyperæsthesia, and various abnormal sensations, such as pricking, tingling, numbness, &c.

The *thermal sense* is generally lost in proportion to the loss of the sense of touch, and over the same area; in very many cases, how-

ever, in which complete anæsthesia is not present, there is no power to discriminate between heat and cold. The amount of loss may be easily determined by making the patient dip the fingers into water of different temperatures, or else by touching the skin of the affected part with some steel implement which has been heated to a certain degree in hot water.

The *anæsthesia* which follows nerve section is generally to the patient the most obvious result of the injury he has sustained, but the extent to which it is present requires an immense amount of time and care to estimate. The best mode of testing the tactile sense in different parts of the body is to measure the exact distances at which the two points of a pair of compasses can be detected as such, but, in addition, the power of localization must be duly estimated. For general purposes it is best to try roughly to find the presence or absence of anæsthesia over a given area by lightly touching the skin with the point of a pencil or pen-holder, and then to proceed to map out the exact amount of anæsthesia with a pair of compasses and a rule.

The patient should always be placed in such a position that it is impossible for him to see the hand of the surgeon, or the area which is under observation; he should not be allowed to move the finger or other part touched, for thereby the muscular sense comes to the aid and falsifies observations; the impact of the instrument used should be very light, for, as Létievant has shown, a patient can frequently discern friction on an anæsthetic surface by means of vibrations carried by the tissues to surrounding healthy nerves. The distances at which the points of a pair of compasses can be detected as such have been given approximately by physiologists, but are almost valueless in testing the sensation on the hand of a working man, in whom the cuticle is so thickened and horny as to be insensible to slight contact of any kind. It must also be remembered that the distance at which the two points of the compasses can be distinguished varies according to whether they are applied in the long or transverse diameter of a digit.

The readiness with which a patient can recognize friction when applied to an anæsthetic finger requires more than a passing notice, for it is liable to become a very fertile source of deception. I have often seen the sensory power of a presumably anæsthetic area tested by rubbing the part with the finger while the patient's eyes were averted, and almost always with the result that the stimulus was correctly perceived, and that a returning sense of touch was

diagnosed by the investigator. Such a conclusion is entirely erroneous, for, as Létievant has pointed out, any person can perceive friction applied even to the finger of *another person* when held between the bases of two fingers of his own hand—*i.e.*, the vibrations are conveyed to, and appreciated by, the nerves of the surrounding digits. How much more must this be the case when, as happens after division of the median, healthy nerves exist on the same finger to which the friction is applied. Friction should therefore never be used as a test of sensation. For the same reason the part which is being examined should never be pushed or thrust away from the position in which it lies; this, I think, needs no further explanation.

If, then, the parts supplied by the terminal branches of the divided nerve be tested with every care, it will be very frequently found that they are not completely anæsthetic, even in cases of complete section of the trunk. A careless examination in such a case might readily lead to the belief that the nerve had not been divided, and that such operative measures as might otherwise have been considered advisable were no longer necessary. The merit of first drawing attention to this condition is due to M. Richet, in a case observed by him in 1867, and since that date the theory of “nerve anastomoses” has been so largely accepted that some authors—*e.g.*, Létievant, Arloing, and Tripier, &c.—have applied it to explain symptoms many of which were undoubtedly due to true regeneration. Now, in far the larger number of cases, it becomes very difficult to say for certain whether the power of distinguishing touch is really due to regeneration, or to nerve anastomosis, and only an examination of the divided ends can set the matter at rest. In others, where the section has been very recent, and the distance separating the upper from the lower end precludes the possibility of union, any tactile sense must be referred likewise to the influence of nerve anastomoses.

On the other hand, in many cases a careless examination will lead the surgeon to the conclusion that all sense of touch is absolutely lost, that the part is completely anæsthetic, and, consequently, there are not a few who deny the presence of any tactile power in the paralysed part, and who, consequently, discredit the theory of “nerve anastomosis.” From my own observations I can have no doubt that in most cases of neurotomy a *complete anæsthesia* is certainly present, and that there are all grades of gradually increasing sensation till we reach a point at which it becomes

exceedingly difficult to say for certain that the tactile sense is not due to a regeneration of the divided nerve. The amount to which this supplementary sensation is present varies according to the nerve divided, and even then is by no means at all constant. As a proof of its reality I shall quote at length the following cases:—

“A young woman fell and sustained a cut across the wrist, completely dividing many of the tendons and the median nerve. Convinced that all the parts supplied by the nerve were insensible, M. Richet wished to show to his assistants the result of section of a nerve, but, to his great astonishment, the patient had retained tactile sensibility. She felt very well when he touched the thumb, middle and ring fingers. The ends of the nerve were united by a silk thread, and the hand maintained in a flexed position. Three hours afterwards, M. Richet had the patient examined by MM. Pajot and Denouvilliers, who also established the retention of sensation in the median distribution, by touching the palmar surface of the hand with a piece of lint or paper while the patient's eyes were covered. Sensibility, intact in the thumb, middle and ring fingers, and palm of the hand, was dulled in the last phalanges of the index. Everywhere else the patient clearly perceived when touched or pricked. As regards temperature, she was sometimes mistaken, taking a cold object for a hot, and *vice versa*.”*

“L., aged fifty-five years, was admitted into the Rouen Hospital in October 1862, suffering from phthisis, of which he died. He had been injured at the age of eighteen by a piece of a broken pitcher, which had made a deep wound in the tissues on the front of the forearm above the wrist. This wound, which reached from one side to the other of the forearm, had been followed by an abundant hæmorrhage, and for six months the hand was kept immovably fixed by orders of his doctor; nothing was ligatured. The hand and the fingers, at first cold, became by degrees warmer, or at any rate the patient ceased to notice the sensation of cold. Soon after the forced flexion was given up he recovered the entire use of his hand, and followed the occupation of a butler.

“When L. came under our observation, we ascertained that movements were almost as good on one side as the other; nevertheless, his grasp is stronger with the right hand than with the

* Richet, *Gaz. des Hôp.*, 1867.

left. He has analgesia, without absolute anæsthesia, over the median distribution.

“The following was the condition found at the post-mortem examination. The cutaneous cicatrix adhered closely to the subjacent tissues by firm scar tissue; the tendons, over a space of three centimetres, had a yellow red tinge, instead of their usual opalescent appearance. At the place of the section, over a length of one centimetre, the parallelism of the fibres was lost, being so mixed that the tendon of the long supinator divided into two parts, and was partly continuous with the long flexor of the thumb; the tendon of the palmaris longus united itself to a mass chiefly composed of the lower ends of its tendon, of the median nerve, and of the upper end of the radial artery. The median nerve below the wound exhibited an olivary swelling 25 millimetres long and 10 millimetres wide, the end of which was continuous by three slender cords with the inter-tendinous fibrous tissue. The lower end of this nerve was so intricately bound up with the tendons of the palmaris longus, the flexor longus pollicis, and the flexor sublimis digitorum, that it was impossible to find the least continuity with the upper end. The rest of the nerve in the forearm, palm, and fingers showed nothing abnormal in size, colour, or consistence.”*

Thus, adds M. Paulet, after thirty-seven years, no trace of reunion was found, but nevertheless sensibility was not lost.

Baudens † records the following case:—“In 1836, a Zouave, aged thirty, received a sabre-wound in the axilla, which divided many muscles, the axillary artery, and the median, ulnar, internal cutaneous, and musculo-cutaneous nerves. The cut ends of the nerves were approximated by silk sutures passed through the surrounding cellular tissue. The limb remained warm, and after twenty-four hours the least pressure on the hand and fingers was painful. During the following days sensation became blunted, but so long as the patient lived no cutaneous anæsthesia could be established in any part of the upper extremity. Eight days after the accident the patient died from hæmorrhage, and the post-mortem examination showed that the nerve-ends were not united, or even in contact.”

* Leudet and Delabost, *Gaz. Med.*, 1864.

† Reported by Létiévant, p. 110.

Dr. Israel * “gives an account of the post-mortem examination of a man who, in 1848, had received a shot in the region of the left shoulder. The bullet made its entrance at the lateral margin of the pectoralis major and came out at the lower third of the scapula. In the last six months of his life, the patient had exhibited symptoms of chronic brain disease, apoplectiform fits, headache, paralysis of the left facial nerve, and mental disturbance. In September 1880, he had repeated attacks of giddiness, tremor (especially in the left arm), vomiting, and singultus. He died in a fit of this kind, September 9, 1880. On examining the patient, four weeks before death, Dr. Brieger found the following condition of the left upper extremity:—Considerable atrophy of the whole arm, but particularly of forearm and hand; thumb extended. Passive movements in the joints of left thumb impaired. Active mobility of shoulder; elbow and wrist perfectly free. Second and third phalanges flexed and greatly atrophied. Tendons in the palm distinctly discernible on account of atrophy. Flexion and extension of hand free; abduction and adduction impossible. The difference of circumference of the arms varies from 2–3½ centimetres; difference of temperature from 0°.6–3°.3 Centigrade in the different parts of the extremities, the greatest difference being in the palms of the hands. Direct electric excitability of biceps, triceps, deltoid, and extensors of hand normal. Direct electric irritability of the left ulnar nerve, faradic as well as galvanic, entirely abolished. Tactile sensibility of left palm distinctly diminished; perception of temperature slightly so. Perception of pain not impaired. Otherwise, no alteration of sensibility to be found.

“The autopsy revealed a tumour in the centre of the left hemisphere, chiefly occupying the insula and part of the third frontal convolution. Internal capsule and pyramidal strands intact; nucleus lentiformis partly affected. In the spinal cord the substance of the middle and lower part of the cervical region distinctly asymmetrical, the left side being considerably smaller than the right.

“Muscles of left upper arm a good deal atrophied; those of forearm emaciated in an extreme degree. There is a cicatrix of 3 centimetres by 0.5 centimetre on the lateral margin of the pectoralis major.

“From this cicatrix strings of connective tissue penetrate the

* Virchow's *Archiv*, vol. lxxxv.; reported in *Brain*, part xv.

muscles crossing the great brachial nerves. The ulnar and median nerves form a regular loop ending in the cicatrix; they unite by an intermediate piece of nervous tissue; each of them shows an intumescence of 2 centimetres length and 1.5 centimetre in diameter. Both nerves have the diameter of a pencil. The radial nerve is but slightly entangled in the cicatrix. In striking contrast to this condition, the peripheral parts of the ulnar and median nerves are considerably atrophied, their diameter being that of a knitting-needle. Having passed through the fascia of the arm, they enter into a direct union with the cutaneous median nerve, which appears thicker than usual. Microscopically, the termination of both nerves show real nervous tissue, whereas the peripheral parts consist chiefly of connective tissue. It need hardly be mentioned that the alterations of the left arm were due solely to the injury, and not to the cerebral tumour. The integrity of sensibility, which was almost perfect, is explained by the communication of the injured nerve with the median cutaneous nerve. It is a remarkable fact, however, that, in spite of this detour, the sensory impressions in the ulnar region were localized in the same way as before the injury, whereas the centrifugal action of the motor nerves had not been restored."

In the *Lancet* of August 1, 1868, Mr. Savory describes a case of neuroma, in which he excised a considerable portion of the musculo-spiral nerve with the tumour. The following is his description of the state of the parts after the operation:—"From the time of the operation the muscles of the back of the forearm were paralysed, and the hand dropped forward from the wrist; but when testing the sensibility of that portion of the skin of the hand which is supplied by branches of the radial nerve, we were not a little astonished to find that it was but slightly impaired. When the skin upon the outer part of the back of the hand, or over the back of the thumb and forefinger, was slightly pricked, the man cried out sharply. He could distinguish in the same region two points of contact, when they were not less than an inch apart, both in the long and transverse axis of the hand; when they were closer than this, on any part of the back of either hand or forearm, he confused them; and, indeed, in comparing the sensibility of this region with that of the inner portion of the back of the hand and two inner fingers, or with the corresponding part of the opposite hand, no very striking difference could be detected.

“All portions, too, of the back and sides of the middle finger appeared equally sensitive. He could distinguish also between the contact of hot and cold bodies in this region as well as in other parts. He always remarked the distinction between the touch of a cold steel sound and one that had been previously dipped in hot water. When desired to experiment on himself by touching, scratching, or pricking the different parts, he repeatedly declared either that he could perceive no difference of sensibility, or that the radial portion of the dorsum of the hand was rather more sensitive than the other half. These observations were carefully repeated in various ways, day after day, with a uniform result; indeed, the man at last got tired of them, concluding, no doubt, that the existence of acute sensibility had been abundantly proved. It need hardly be said that, in many of these experiments, the man was blindfolded, and otherwise prevented from forming any idea of what we did, except through the sense of touch.

“Now, what is the interpretation of this remarkable fact? All anatomists will agree that, so far as ordinary dissection goes, the skin on the outer half, or thereabouts, of the back of the hand, and of the back of the thumb, forefinger, and outer portions of the back of the middle finger, is supplied only by branches of the radial nerve; and when any variation is witnessed in the distribution of this nerve to the back of the hand, it is almost always that it supplies more than the usual portion of integument, going on sometimes to the ring-finger. I cannot doubt, therefore, that in this instance the parts in question were supplied in the usual way, only through the branches of the radial nerve. But, then, how could these parts retain sensibility after the removal of some inches of the nerve-trunk? I can only account for it thus: we know that in the forearm, just above the wrist, some small branches of the external cutaneous nerve communicate with the radial, and it may be that at this junction the radial receives filaments from the external cutaneous, which so pass down to be distributed with the filaments of the radial even to the skin of the hand. This seems to me the most probable view of the matter—indeed, the only reasonable one.”

The next case was reported by Mr. Butlin, in vol. xxv. of the *Pathological Society's Transactions*:

“D. D., aged thirty-two, was admitted into St. Bartholomew's Hospital with a broken back (in June 1873), of which he died three

or four days after admission. There was noticed on his left forearm, three or four inches above the wrist, a long oblique scar, apparently the remains of a tolerably deep and severe wound; the ring and little fingers were exceedingly contracted, the little finger especially drawn in towards the palm. Neither of them could be at all straightened; the skin covering them was tense and glazed. The muscles of the ball of the little finger were atrophied to an extreme degree and contracted. The interossei and abductor indicis, the abductor pollicis and the inner head of the flexor brevis pollicis, were in the same condition. But, as far as could be ascertained by careful examination, there was no loss of sensation, feeling being as complete in one hand as in the other.

"The history which he gave of this—for he was in complete possession of his faculties until shortly before his death—was as follows: that fourteen years previously his forearm was wounded, and he was in the hospital for fourteen weeks. At the time of admission, and for some time afterwards, the hand was 'numb' on the inside. He regained feeling in it before he went out; his fingers became drawn down afterwards.

"A post-mortem examination showed that the ulnar nerve had been completely divided about three and a half inches above the wrist. The upper portion was firmly united to the anterior surface of the tendon of the flexor carpi ulnaris; the lower portion was united to the same tendon, but to its posterior and external aspect. No communication whatsoever could be discovered between the extremities of the divided nerve, which were not only far apart, but also on a totally different plane.

"The upper portion showed very little atrophy, even when examined with the microscope. About three-fourths of an inch above its point of union with the tendon was a large bulbous swelling, similar to the swelling found at or about the ends of nerves in stumps. The lower portion of the nerve was exceedingly atrophied. Sections examined microscopically showed that it was composed almost wholly of connective tissue, but here and there could be seen small points which had been deeply coloured with carmine, and which resembled axis cylinders."

The manifest care expended on a thorough investigation of the recorded cases, and the high reputation of many of the surgeons under whom the patients happened to be placed, leaves little or no room for doubting the reality of the retention of a certain amount

of sensation in the area supplied by the divided nerve. The more care, then, is necessary in arriving at the conclusion that, in the case of any injury, a regeneration and reunion of the divided ends has occurred; for, if the surgeon disregard the possibility of a supplementary nerve-supply, he is apt to refer any signs of returning sensation to a reunion of the nerve, and not to its true cause.

In addition, then, to testing the tactile power and amount of anæsthesia, it is necessary to note the presence or absence of trophic change. If coincidently with a gradually returning sense of touch, the nutrition of the part improves; if previous trophic lesions pass away; and if, what is most important, the atrophied muscles resume their normal bulk, their reaction to faradism and their contractile power, it may fairly be considered proved that a reunion of the divided nerve has occurred. But, in the absence of these additional symptoms of regeneration, *a simple return of sensation does not afford sufficient proof of new nerve formation.*

With regard to the extent to which this supplementary sensation (*sensibilité suppléée* of Létievant) may be present, Létievant writes:

“These supplementary sensations are very imperfect, but, in proportion to the length of time which has elapsed since the section, they undergo by use a greater development. . . .

“It is modified by certain local pathological conditions. Thus, after certain nerve divisions, practised chiefly for neuralgia, there is produced a sort of local stupor which masks the supplementary sensibility for a few days. Sensibility is gradually restored as this stupor is dissipated. . . . Supplementary mobility and sensibility have a variable duration—temporary in some cases, they are permanent in others.”

With these remarks, my own experience would lead me to agree; and I would only add that, in some cases, the supplementary sensation appears to be most marked immediately after the nerve section, and that it subsequently disappears.

The manner in which this sensibility is kept up is thus stated by Richet: “As both the loops and filaments which end in the touch corpuscles are compound, containing fibres from the median, radial, and ulnar nerves, section of one of these trunks is powerless to deprive of sensibility the corpuscles, which are the essential organs of touch.” This is *à propos* of a division of the median.

Arloing and Tripier* express much the same opinion, and state that, after division of three out of the four collateral nerves on the toe of a dog, sensibility still remains, but is destroyed by dividing the other nerve. This, however, is certainly not applicable in its entirety to the human subject, as there can be no doubt that in many cases—*e.g.*, after division of the median at the wrist—the fingers are, in parts, frequently entirely anæsthetic. Israel, in the case quoted by him, is inclined to ascribe the cause of the supplementary sensation to a chance union of the proximal ends of the injured nerves with another nerve which was yet intact; this condition, however, is not essential for the presence of supplementary sensation.

Mr. Savory, with more probability, refers this condition to what I may call the “coarse anastomoses,” in contradistinction to Richet’s explanation, and in the case of injury to the musculo-spiral, on which he bases his arguments, instances the union of small branches of the external cutaneous with filaments of the radial nerve. No difficulty need be found in accepting either Richet’s or Savory’s explanation: it has already been pointed out that the nerves can transmit currents equally well in either direction, and, considering the comparatively small bonds of union which exist, and the fact that they do not enlarge as do the collateral vessels after ligature of an artery, the imperfections of the supplementary sensations will not excite surprise.

In addition to simple inability to perceive the contact of various bodies with the skin, there is often found a want of power to localize correctly the exact spot touched. Frequently a patient will perceive that some part of the hand is being touched, but, on being asked to name the finger or spot of contact, he makes mistakes. Thus, on pricking the back of the finger, he fancies that it is the front which is being experimented on, or else another finger, or else even the palm or back of the hand. In my experience, there seems to be no particular law as to this transference of sensations—sometimes the patient fixes on a spot which is really devoid of sensation, at other times on a sound digit. The sense of pain, as evinced by pricking or pinching, is generally lost in proportion to the amount of anæsthesia, but in a considerable number of cases all sense of pain is absent, and yet there is not complete anæsthesia; the reverse is rarely the case. In my opinion, this is due to the fact that a more intense impression is necessary to give

* *Annales de Med. Vet.* 1876.

rise to pain, and that a proportionately perfect nerve-supply is requisite, while the sensation of touch can be more or less clearly perceived, even when the nerve paths are more or less damaged.

In rare cases, the skin may be in an hyperæsthetic condition; this, I think, only occurs in cases of incomplete section, in conjunction with neuritis as a rule, but sometimes apart from this in the *neighbourhood* of trophic lesions, and at the junction of anæsthetic with healthy skin.

The *muscles* supplied by the divided nerve are paralysed by its section, and the subsequent changes which take place in them have been already described. It remains, however, to notice the deformities which result from their atrophy.

The exact method by which the altered condition of a muscle after nerve section causes contractions and deformities appears to be very imperfectly understood. It is generally spoken of as if it were an active contraction either of the muscle itself or else of the degenerated tissue which takes its place. I believe that this view is not correct. The muscle undergoes atrophy, it shrinks and grows smaller in every diameter, but not with any degree of force sufficient to cause actual deformity. No, the whole secret of the process lies in the fact that *the muscle shrinks only so long as it is unopposed*; if, therefore, its origin and insertion be unduly approximated *during the process of atrophy*, they will remain in such a condition when the trophic changes have ceased, not because they have been drawn together by such changes, but that the atrophy found them in a certain position and fixed them there. For instance, after section of the median nerve in the upper arm, it is very common for permanent flexion of the digits to ensue, but the reverse is not the case after the division of the musculo-spiral; the fingers and wrist are not then extended, but, on the contrary, are flexed. Whence the difference? I think it is easily explicable. When the hand is paralysed, or when it is simply not in use, the fingers naturally lie in a position of flexion, and in this position they are gradually fixed by the trophic changes. There is evidently no active contraction, for if it occurred in the flexors in the case of division of the median, the same result ought to follow in the extensors on section of the musculo-spiral, and hyper-extension of the fingers and wrists would result. This condition is prevented, however, by the naturally bent position of the hand, and by the frequent exercise of the flexors. Similarly, after infantile paralysis, the

most common deformities are equinus and bent knee. But in many cases the whole of the muscles of the lower extremity are equally paralysed; why, then, are not the leg and foot sometimes extended? Simply for the very good reason that both of them, either in sitting or walking, but more especially the former, naturally fall into the position, in which they are subsequently fixed, by the shrinking of the muscles which occurs at a period when from the nature of the illness the patient is unable to take active exercise.

I am then very strongly of opinion that the "irresistible power of contraction of the paralysed muscles," described by some authors, has no existence in fact, but am quite willing to allow that, when shrinking has once occurred, the muscles cannot be restored to their normal length. There is, however, one form of active contraction which is sometimes very troublesome—namely, that which is due to the unbalanced action of the unaffected muscles; it may produce a real deformity, though not, I think, very frequently.

The changes in the electric irritability of divided nerves appear to commence very early after section. MM. Cossy and Dejeune found that after section of the sciatic in guinea-pigs, the excitability of the peripheral segment is diminished on the second day, and after the third is entirely lost. Leegard* says that at first the irritability of the divided nerve—*i.e.*, of its distal end—is slightly increased in some cases, but not constantly, and agrees with the above observation that by the third day it no longer reacts to electricity.

The electrical condition of the muscles has been already referred to in speaking of trophic changes, and the extent to which a muscle will respond to electrical stimuli after nerve lesions has been made by some authors a point of great importance in the prognosis of such injuries. It must not, however, be thought that the absence of all reaction to the proper stimuli in any way indicates that motion is permanently lost, for, as we shall see presently, if the continuity of the nerve be re-established, regenerative changes will take place in the muscle, at any rate for a considerable time after the date of the original lesion.

But although the failure of a muscle to react to electrical stimuli is not by any means to be considered an indication that it is beyond recovery, the behaviour of the muscle to the electric

* *Archiv für Klin. Med.*, 1880.

current nevertheless affords the most valuable evidence as to its connection with its trophic nerve-centre.

On examining a muscle in a natural condition with a galvanic current, it will be found that the kathodic closure contraction (K.C.C.) is greater than the anodic closure contraction (A.C.C.), a condition which is briefly expressed by the formula $K.C.C. > A.C.C.$

It has been shown by Erb* that, in a muscle separated from its motor nerve, this reaction undergoes a marked change, the A.C.C. becoming first equal to and then greater than the K.C.C., which, together with other electrical conditions, go to make up the so-called "reaction of degeneration."

This alteration in the electrical reaction of the muscle is well and briefly put by M. Nicaise.† He says:

"During the first fifteen days the faradization curve becomes gradually depressed. After the third week the muscle is no longer excitable—at least, through the skin. Towards the sixth week, in favourable cases, the excitability reappears, and gradually increases until it reaches the normal reaction.

"But the galvanization curve follows an entirely different course. During the first fifteen days it follows the faradization curve; but from the third week, when the interrupted currents have no longer any effect, the galvanic reaction is exaggerated, the curve is raised, soon exceeding the normal, and reaches its maximum when the other is at its minimum. At the moment that repair begins to take place the phenomena follow an inverse order; and at the same time that the faradic curve is raised the galvanic curve is lowered, and both gradually return to the normal level. If, instead of a favourable case, we suppose a case in which the regeneration of the nerve does not occur, there is no ascent of the faradic curve, and the galvanic curve, after being elevated, falls again to the normal, and then continues to sink until the reaction becomes *nil*."

The above paragraphs form a very accurate summary of the conclusions arrived at by Erb and other experimenters. The care with which the results have been recorded leave no doubt in my mind as to the accuracy of the observations, and it only remains to notice, before proceeding further, that these conclusions are the result of experiments on animals and not of clinical observations on man. These experiments I have not myself repeated, because I

* *Handbook of Electro-Therapeutics.*

† Article in Ashurst's *Encyclopædia of Surgery*, vol. iii.

have no doubt that the conclusions arrived at are correct. Moreover, inasmuch as I am interested more particularly in the nerve injuries of man, I have found that I could better occupy my time by examining the electrical reactions in the muscles after severe injuries, such as are met with clinically. And here I would point out again that the changes that occur in the nerves or in the parts supplied by them, as noted by experiments on animals, do not necessarily find their exact counterpart in similar conditions in man. This is a point that is duly appreciated by Nicaise, who says, after concluding the paragraphs I have quoted: "Do the same phenomena occur in man as in animals which are made the subject of experiment? Precise observations are not sufficiently numerous to permit this fact to be definitely affirmed. A minute study of these electric phenomena in the traumatisms of nerves is then necessary before we can apply with certainty to man the results observed in animals."

With this I entirely agree, but have so far searched in vain amongst the now numerous recorded cases of nerve injury for any information on this point. My own observations, however, lead me to disagree with Erb, in some particulars at least; and I would take the present opportunity of acknowledging the valuable assistance I have received from Dr. Steavenson, electrician to St. Bartholomew's Hospital, who has very frequently examined patients in whose cases I have been specially interested.

I have found that in cases of nerve section the faradic excitability of the paralysed muscles has disappeared with much greater rapidity than in animals; for, whereas Erb states that it gradually fades and finally disappears in the third week, I have found absolutely no reaction to the strongest current as early as the third or fourth day. In one case only did excitability persist until the eighth day. With regard to the galvanic current, there is again a marked difference between the condition in man and animals. In the latter the galvanic irritability of the muscles is said to become greatly increased at the second week, and in the third week the excitability is so great that contractions are excited by the current evolved from only two or three cells.

Such is not my experience. I have never seen but once—and then it was doubtful—the least increased excitability. On the contrary, I have found that the galvanic irritability diminished rapidly, so that in two or three weeks, at a time when, theoretically, excitability should be at its height, strong currents produced

but slight fibrillar contractions. And whereas, by experiment, the date of the final disappearance of galvanic excitability has been fixed at about eight or ten weeks, I have found it to vary in man from about the third to the sixth week at the latest.

With regard to the alterations in reaction to the kathodal and anodal closure currents, my own observations are in accordance with those of others. I have found that the anodal closure contraction, about a week or ten days after injury, was either equal to or greater than the kathodal closure contraction. This reaction is of great value from a diagnostic point of view, and is also most reliable. Considerable care is nevertheless requisite in investigating the affected muscles.

The next point for consideration is the permanency or otherwise of these altered reactions. Supposing that at the end of a few weeks all electrical excitability has disappeared in the paralysed muscles, when must we look for its recurrence? and in what way does its absence influence the prognosis? To this it may be answered that if the divided nerve does not reunite, the electrical excitability will not return; but that if it does unite, *voluntary power will return before electrical excitability*.

The first sign of repair as regards the muscles must not, then, be looked for in the electrical reactions, but in the return of function; and the continued absence of electrical irritability is not to be looked upon as sufficient ground for a bad prognosis. Voluntary power often returns many months, or even a year or more, before electric excitability—a fact which is difficult to explain, but of which I cannot have the slightest doubt.

Does faradic or galvanic excitability return first? I cannot answer this question quite so definitely as some of the others. In some cases both have returned at the same time; in others the muscles have contracted to the faradic current whilst yielding no response to galvanism. I have never seen galvanic irritability return before faradic. In most of the cases I have observed, the galvanic reactions, when they first reappeared, were normal in quality, but in one case, where they did not return until six months later than the faradic reaction, the reaction of degeneration was well marked. The following notes of cases illustrate most of these points:—

CASE I.—James D., aged thirty-four, divided his ulnar nerve on April 7th.

April 9th.—No reaction to faradism of ulnar muscles. Good reaction to galvanism of ditto.

14th.—No reaction to faradism. Very slight reaction to galvanism.

CASE II.—George H., aged thirty, divided his ulnar nerve on May 8th.

May 11th.—Muscles supplied by ulnar nerve react to faradism; to galvanic current A.C.C. = K.C.C.

13th.—Complete loss of faradic contractility in all the muscles supplied by the ulnar nerve. Very slight reaction to galvanism.

CASE III.—Emile M., aged forty-seven, divided ulnar nerve at elbow on February 22, 1884.

Feb. 25th.—Faradic current. No reaction of muscles supplied by ulnar nerve.

CASE IV.—John J., aged thirty, divided his ulnar nerve at the wrist on February 23, 1885.

Feb. 24th.—Faradic current, all muscles react. Galvanic current, K.C.C. > A.C.C. No increased irritability. Ulnar muscles paralysed.

26th.—Faradic current, slight reaction of interossei. Galvanic current, A.C.C. = K.C.C. No increased irritability.

27th.—No change.

28th.—Faradic current, marked diminution of excitability. Galvanic current, in third interosseous muscle A.C.C. > K.C.C. Other interossei as before.

March 1st.—Faradic current, only the faintest contraction. Galvanic current, A.C.C. > K.C.C.

4th.—No reaction to faradism. The faintest tremor to galvanism.

CASE V.—Henry B., aged forty-seven, divided his ulnar nerve on February 6th.

Feb. 28th.—Complete loss of both faradic and galvanic contractility.

CASE VI.—Annie B., aged twenty-seven, divided her median nerve at the wrist on September 27, 1885. On account of the hand being entirely covered with antiseptic dressings, I was unable to examine the condition of the muscles until the third week.

On October 20th there was found to be no reaction to faradism in either the opponens or abductor pollicis. The same muscles gave the reaction of degeneration to the galvanic current (A.C.C. > K.C.C.), but instead of there being marked excitability there was great loss of galvanic irritability, and the contractions were slow and wavy.

Oct. 30th.—The muscles supplied by the median nerve require eighteen more cells to cause a contraction than do those of the other hand, and then scarcely react.

It will thus be seen that after nerve section the paralysed muscles usually fail to contract to the faradic current after the third or fourth day. That at the same time, tested by the galvanic current, A.C.C. = K.C.C., and later on A.C.C. > K.C.C. In three to six weeks there is complete loss of all electric excitability.

In support of my statement that voluntary power returns before electric excitability, I append the following extracts from cases I have observed:—

CASE I.—J. C., aged seventeen, divided his musculo-spiral nerve on March 25, 1883.

On April 28th the operation of secondary suture was performed.

On July 27th there was some return of power in the previously paralysed extensor muscles, but no return of electric excitability.

On Nov. 16th there was almost perfect restoration of power, but no reaction to galvanism or faradism.

On March 25, 1884—one year after the injury—there was complete restoration of voluntary power, but still no electric excitability.

Oct. 9, 1884.—Wrist extensors and extensor ossis metacarpi pollicis react to faradism and galvanism, but the extensors of the phalanges of the fingers and thumb do not react.

CASE II.—T. M., aged twenty-four, divided his median nerve on July 20, 1882.

May 5, 1883.—The divided ends were sutured.

Nov. 26, 1883.—Return of power in opponens and abductor pollicis. No reaction to galvanism or faradism.

March 28, 1884.—Muscles quite as good as on other hand. Very slight reaction to a strong faradic current.

Sept. 22, 1885.—Reaction normal to faradism and galvanism.

CASE III.—W. W., aged nineteen, divided his ulnar nerve at the wrist. Seven months later the divided ends were sutured. In five months there was return of voluntary power in the interossei and muscle of the ball of the little finger. A year later the hand was quite well, but there was yet no reaction to electrical stimuli.

CASE IV.—C. R., aged eleven, divided her ulnar nerve in the forearm. Three months later secondary suture was performed. Muscular power began to return in about eighteen months. Six months later the muscles supplied by the ulnar nerve reacted to faradism, but not to galvanism. After an interval of another six months galvanic irritability was restored, but the reaction of degeneration was well marked.

Punctured Wounds of Nerves and Partial Division.

—For many years it was taught that a partial division of a nerve was more likely to be followed by serious complications and by severe trophic lesions than was complete division.

Such is, I believe, an altogether erroneous idea. On the contrary, the less of the nerve divided the less is the anæsthesia and paralysis, and the fewer the trophic lesions. Further, as the divided ends in such cases are not separated, union is more likely to be rapid and perfect than in cases of complete section. The following cases may be quoted in support of these statements:—

Punctured Wound of Posterior Interosseous Nerve. Gradual Recovery.

Henry C., aged eleven years, was admitted into St. Bartholomew's Hospital on January 3, 1884. On December 24, 1883, he fell on some wood and sustained a wound on the posterior surface of the forearm two inches below the elbow-joint. On admission there was found to be suppuration amongst the muscles of the back of the forearm. The muscles supplied by the posterior interosseous nerve were paralysed.

Jan. 12th.—Electrical Examination. No reaction to either galvanism or faradism of the extensors of the wrist, fingers, or thumb. No loss of sensation.

March 1st.—Is faradized daily.

10th.—Slight reaction to faradism. There is now no wrist-drop.

28th.—Discharged, further improved.

April 24th.—Can extend the wrist, thumb, and fingers. Good reaction of the thumb extensors and of the extensor indicis, extensor carpi radialis longior and brevior to faradism. Reaction of the three inner fingers and of the extensor carpi ulnaris very feeble.

Punctured Wound of Median Nerve.—Gradual Recovery.

William C., aged fourteen, was admitted into St. Bartholomew's Hospital, April 27, 1883. He had cut his forearm a month previously by putting his hand through a pane of glass. From the time of the accident some of his fingers had been very numbed. Condition on admission: A wound an inch and a half above the wrist, immediately over the course of the median nerve, almost completely healed. No tenderness, but pressure on the upper lip of the wound causes tingling in the median distribution. This tingling is not felt on pressure lower down the wrist. Sensation: Absent to all stimuli over the front of the thumb, index and half the middle finger, also over the back of the index and middle, as far down as the middle of the first phalanx. Impaired over the other half of the middle finger and the radial half of the ring. Trophic: No trophic changes. Muscles: He can oppose the thumb, though feebly.

June 28th.—No wasting of muscles. Sensation improved over the middle finger so that he can accurately localize a touch on any part of the palmar surface. Trophic: The nails of *all* the fingers are ridged, toothed, and furrowed. The hand is painful when cold, but not otherwise. Ordered to use a stimulating liniment.

July 26th.—Sensation much improved in the middle and index fingers. No other change.

Nov. 26th.—The nails are now all quite natural. Sensation has improved in all the fingers.

March 25, 1884.—Hand is useful and strong. He says he can do anything with it. Electrical examination: No faradic contractility.

Oct. 8th.—No further change.

March 26, 1885.—Sensation much improved. Can localize everywhere, but still complains of numbness. No electrical reaction of opponens pollicis.

July 9th.—The condition of the hand is practically natural, but there is still no electrical reaction.

Sept. 24th.—Reaction of all the thumb muscles to both

faradism and galvanism. There is slight loss of faradic excitability.

Partial Division of the Median and Ulnar Nerves.—Gradual Restoration of Function.

E. M., aged thirty-four, cut her wrist severely in August 1883. There was much hæmorrhage at the time, and she lost sensation and use in the hand. Two months later she noticed blisters on the tips of the index, middle, and ring fingers, which appeared without any injury having been suffered. These blisters subsequently suppurated, but caused her no pain except in the case of the ring-finger.

On Nov. 7, 1883, she was found to have marked reaction of degeneration of all the muscles of the thumb, interossei, and lumbricales, but the muscles of the ball of the little finger acted fairly well. There was no reaction to faradism of the muscles which showed the reaction of degeneration. Sensation: Lost to all stimuli over the radial side of the palm and on the palmar surface of the thumb, index, and middle fingers. Impaired over the back of the first three metacarpal bones, and over the first and second phalanges of the index, middle, and thumb. No sensation over the posterior surface of the third phalanx of the same digits. The palmar surface of the ring and little finger and the skin of the ulnar side of the palm were anæsthetic. The dorsal surface of the ulnar side of the hand and of the ring and little fingers had its sensation much impaired. The nails were serrated and broken; the hair was natural.

March 26, 1884.—The hand is numb and cold. It is painful when cold, but not otherwise. There is general improvement in sensation, more especially on the palmar surface of the thumb. All the muscles are much wasted. The hand is flat and thin. She has no power of opposition or abduction of the thumb. There is no reaction to faradism of any of the muscles of the hand. The patient says that the hand is improving, and that the ring and little fingers feel much better than the others. She also feels the faradic current in them much more acutely than in the rest of the hand. She has some power over the muscles supplied by the ulnar nerve, but none over those supplied by the median.

Oct. 16th.—She says the hand has much improved and is improving. She has no pain, but the hand sometimes becomes suddenly stiff. There are bulbs to be felt over the median and

ulnar nerves beneath the scar. These are tender on pressure. There are no trophic changes except that the joints are a little stiff and the hands a little cold. The interossei muscles are wasted and the hand is slightly clawed. There is no galvanic or faradic contractility of the muscles supplied by the ulnar and median nerves in the hand; she can, however, oppose and abduct the thumb, and the hand is useful for all ordinary work, but she cannot sew. Sensation has much improved, and she can localize the touch of a pencil everywhere except on the ulnar side of the ring-finger. She says the hand scarcely feels numb except when it is cold.

March 27, 1885.—Not much change. The hand is strong and useful, and does not cause her any inconvenience. The tips of the index and middle fingers are still numb. There is no faradic contractility of any of the muscles in the hand, but none of them are much wasted. The hand is really in very good condition.

July 12th.—There is now both faradic and galvanic contractility of all the muscles of the hypothenar eminence. The hand is altogether better. The muscles of the ball of the thumb, supplied by the median nerve, are more wasted and paralysed than at the time the last note was taken.

I might quote many other cases, but the above are sufficient to show that punctured wounds are not followed by special trophic lesions, and are, on the contrary, less serious than is complete section of a nerve.

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CHAPTER VII.

INJURIES OF SPECIAL NERVES.

IN this chapter I propose to consider the symptoms following lesion of such trunks as are most commonly damaged, for an accurate knowledge of the extent of the motor paralysis and of the accompanying anæsthesia, together with any collateral evidence to be gained by a careful study of each individual case, is of considerable importance in both diagnosis and treatment.

The nerves of the upper extremity are from their situation most prone to sustain damage in many ways. They may be divided by wounds from cutting instruments, may be lacerated together with the other soft parts in many varieties of machinery accidents, and, most often of all, in civil practice may be wounded by the outstretched arm being thrust through a pane of glass, or by falls on breakable articles, such as bottles, jugs, or basins. They may, in addition, be damaged by gunshot wounds or stabs.

Symptoms of Division of the Ulnar Nerve.—Judging from my own experience, and also from a consideration of published cases, I am inclined to believe that the ulnar is, of all nerves, the one most frequently wounded. The commonest situation of an injury to this nerve is immediately above the wrist, just where it comes towards the surface, before passing into the hand. The line of section may be either above or below the point at which the dorsal cutaneous branch is given off, but is most commonly above. In the rest of its course in the forearm the ulnar nerve is greatly protected by the muscles amongst which it lies, but its situation does not prevent its occasional division in this position also. Its scanty covering and exposed situation behind the internal condyle render it very liable to damage, and we consequently meet with more cases of injury in this situation than in the forearm. In the upper arm division is rare, and the symptoms do not differ at all from those we meet with after section at the elbow.



Fig. 15.

FIG. 15.

The palmar surface of a hand some months after section of the ulnar nerve. It shows the wasting of the muscles, the typical position of the digits and the area of anæsthesia. The depth of the shading indicates the amount of anæsthesia.

Loss of Motion.—If the ulnar nerve has been divided above the origin of all its branches, the flexor carpi ulnaris and the two inner tendons of the flexor profundus digitorum are paralysed, and as a result complete flexion of the fourth and fifth digits is impossible, as is also complete flexion of the wrist. The wrist cannot be bent to the ulnar side. The palmaris longus and radial flexors of the wrist supplement to a great extent the loss of power in the flexor carpi ulnaris.

The muscles forming the hypothenar eminence are paralysed, and all movements of the little finger, except that of extension, are wanting. The absence of the power of abduction is very marked, not only in the little finger, but also in the others; for, on account of the paralysis of the interossei, the patient is utterly unable to separate the digits from each other. The loss of power in the two lumbricales is not a prominent symptom; but, on account of their paralysis, and of that of the interossei, movement at the metacarpo-phalangeal joint is deficient.

The adductor pollicis and part of the flexor brevis pollicis are also paralysed, but, on account of the numerous other muscles attached to the thumb, its range of motion is not much interfered with.

If the nerve section has occurred some time previously, the resulting deformity is very characteristic. The wrist is generally slightly tilted backwards and towards the radial side, owing to the frequent and unopposed action of the radial and ulnar extensors and radial flexors. The whole hand is very much thinner than its fellow, the hypothenar eminence is absent, and in its former situation there is frequently a hollow; the metacarpal bone of the little finger is bare and prominent, and the inner edge of the muscles of the ball of the thumb supplied by the median is sharply defined, and raised above the flattened palm. On the dorsal surface the extensor tendons and metacarpal bones stand out in strong relief, and on the radial side of the first metacarpal bone is a very deep depression, marking the site of the atrophied abductor indicis. The thumb is slightly rotated forwards by the opponens pollicis, so that its radial margin presents more than does that of its fellow of the opposite side.

The second and third phalanges of the fourth and fifth digits are flexed, the latter being always the most affected. The position of these fingers merits some attention.

I have no doubt that the site of the injury bears an important

relation to the amount of flexion, and that when the flexor profundus digitorum is paralysed the flexion of the digits is more marked, on account of the atrophic shortening of this muscle. This is, perhaps, only what might be expected; but flexion, though to a less extent, is present even in cases in which the nerve has been divided at the wrist. The deformity assumes the following aspect.

The first phalanges of all the fingers, but more especially of the fourth and fifth digits, are hyper-extended upon the metacarpal bones. In the index and middle fingers the hyper-extension is but slight, and the metacarpo-phalangeal joints can be flexed; the heads of all the metacarpal bones are unduly prominent in the palm. The second and third phalanges of the last two digits are also flexed to a greater or less extent, the fifth finger being always worse than the fourth, and these digits cannot be extended. The little finger is abducted.

A satisfactory explanation of these malformations is not altogether easy. As I have already endeavoured to explain, the paralysed muscles, though contracting, do not do so with any degree of force, so that if the contraction be opposed deformity does not take place. In the case of the thumb and wrist, the movements caused by other muscles prevent this contraction and deformity from occurring; but in the little finger the case is different. The paralysed digits naturally rest in a position of flexion, and in those cases in which the flexor profundus is paralysed, the trophic changes occurring in that muscle meet with no opposition, and the shortening of the muscles fixes the already flexed fingers in the position in which they lie.

It is not by any means so easy to account for the flexion that ensues on division of the nerve at the wrist, for in this case the flexors profundus and sublimis are intact, as are also the extensors of the digits; why, then, should the two last phalanges become flexed and remain incapable of extension?

Before attempting an explanation of this contraction, it will be necessary to consider the cause of another deformity which I have already mentioned—the hyper-extension of the first phalanges on the metacarpal bones.

This is undoubtedly due to the paralysis of the interossei, for the action of these muscles being to flex the first phalanges, and to aid the extensors in extending the last two, the result of this paralysis is that the extensors in acting extend not only the

FIG. 16.

The dorsal surface of a hand some months after section of the ulnar nerve. It shows the wasting of the interossei, the typical position of the digits, and the area of anæsthesia.



Fig. 16.

terminal phalanges, but also the proximal ones; another instance of the fact that the atrophied muscles do not cause any deformity by their *contraction* when this is in any way opposed. The first phalanges of the index and middle fingers are never so much extended as those of the fourth and fifth, and I think this may be accounted for by the fact that the lumbrical muscles attached to these digits, not being paralysed, by their action supplement to a considerable extent the loss of the interossei.

Another set of muscles, whose main action is to flex the proximal phalanx of the fifth finger, is also paralysed—namely, the muscles of the ball of the little finger; but in proportion to the amount of its flexor muscles, this finger is supplied by a special extensor, so that, after ulnar paralysis, the metacarpo-phalangeal joint of the fifth finger is more extended than that of any other.

The flexion of the distal phalanges of the ring and little fingers is to be partly accounted for by the fact that the interossei and lumbricales, which normally assist in extending them, are paralysed. But as the digits have in addition their own common extensor in a healthy state, it is evident that they are yet provided with a muscle which ought to be capable of extending them. The reason why extension is difficult or impossible must then be sought for in some mechanical condition resulting from the nerve section, and this is found in the hyper-extended state of the first phalanges of the affected digits. For a little observation of the movement of the fingers in a normal hand will readily convince any one that it is a physical impossibility to hyper-extend the first phalanx, and to extend the two last phalanges simultaneously. The flexion of the fingers is therefore secondary to the hyper-extension which results from the paralysis of the lumbricales and interossei attached to them.

Loss of Sensation after Division of the Ulnar Nerve.—The parts in which sensation is affected by the division of the ulnar nerve comprise the little finger, back and front, and both anterior and posterior surfaces of the ulnar half of the ring, also a corresponding portion of the dorsum and palm extending upwards to just above the level of the wrist-joint. This area is generally sharply defined, and does not gradually fade into the surrounding healthy skin.

In several cases I have examined, the loss of all sensation of touch, pain, and temperature was absolute in, at any rate, some

portion of this area; and I cannot agree with Létievant in his statement that all sensation is never lost entirely, for I have found the most careful examination fail to elicit the slightest expression of sensitiveness. Hence we must conclude that the deductions drawn by Arloing and Tripier, as a result of their experiments on dogs, does not hold good in mankind; for these observers state that so long as any one of the nerves going to any toe remains undivided, a certain amount of sensation remains in all parts of the digit. In man this is certainly not the case.

But in some cases, undoubtedly, a "supplementary sensation" is established, and appears to improve with use. It is, however, very rarely so nearly complete as to lead to the belief that union, or partial union, of the divided nerve has resulted. This is not at all surprising in the case of the ring-finger, where the close union between the ulnar and median nerves would rather lead one to expect more sensation in the ulnar half of the ring than is generally to be found.

The amount of the anæsthesia present varies in different parts of the anæsthetic area. I have found the little finger itself the most insensible to all stimuli; then the skin covering the head of the fifth metacarpal bone, and in the rest of the area an anæsthesia not so complete. Létievant considers the ulnar edge of the palm the most insensitive spot.

Trophic Lesions.—In addition to the foregoing symptoms, many and various trophic lesions may be present in the parts supplied by the divided ulnar nerve. It is unnecessary to re-describe them at length; but I would just point out that these troubles occur more often in the hand than elsewhere, and that those which may be specially looked for are "glossy skin;" loss of hair; brittle, cracked, ridged, and curved nails; and coldness of the anæsthetic area.

The following cases are good examples of the results of the division of the ulnar, whilst some, in addition, have special points of interest of their own:—

E. W., aged thirty-three, blind-maker, was admitted to St. Bartholomew's Hospital on June 14, 1881. He had fallen through a skylight, and received a severe wound in the middle of the forearm. Some of the superficial flexors were divided, and also the ulnar nerve. The nerve-ends were united by catgut sutures.

June 17th.—Slight return of sensation.

July 28th.—Return of sensation in ring-finger, but not at all in the fifth.

I examined this patient on July 17, 1882. There is a large depressed scar on the inner side of the upper forearm, not painful or tender. Has no power of separating the fingers from each other. Thumb movements rather limited in flexion and adduction. Scarcely any power of movement in fifth finger, and but little in the ring. The inner side of the forearm is wasted, and the wrist slightly bent to the radial side and extended. The appearance of the hand is typical of ulnar paralysis—thin, flattened, and atrophied. The fifth finger is much flexed, the fourth slightly so. Trophic: Paralysed parts feel distinctly cold. He says that the inner part of the hand and the fourth and fifth fingers never sweat. Nails normal. Hair on little finger short and stumpy. Has had no blisters, ulcers, &c. Sensation: Much impaired on inner side of palmar surface of forearm. Fifth finger: He can feel, but cannot localize tactile sensations over palmar surface of first phalanx, but can localize them over second and third phalanges. Much the same condition on dorsal surface. Has no sense of pain, and very slight, if any, appreciation of temperature. Fourth finger: Can localize sensations in all parts, and has very slight perception of pain and temperature. On the ulnar side of the palm sensation to all stimuli is impaired, but not altogether absent. He cannot distinguish the two points of a compass as such in any part of the ulnar distribution.

W. K., aged fifty-three, stableman, admitted to St. Bartholomew's Hospital. July 12, 1879. He had fallen on a basin, and inflicted a severe wound on the forearm, at the inner side about the middle. The flexor carpi ulnaris, two tendons of the flexor sublimis digitorum, and the ulnar artery and nerve were divided.

On July 17, 1882, I examined the condition of his arm. The scar was adherent to the deeper structures, and was not painful or tender. The fourth and fifth digits were slightly flexed, and the distal joints ankylosed. The wrist was slightly tilted back, and there was scarcely any power of forward or ulnar flexion. The thumb, index, and middle fingers were freely movable. There was extreme wasting of the ball of the little finger, which was quite flat, and of the interossei; also a marked hollow on the radial side of the first metacarpal bone. The hand was very thin, and the ball of the thumb slightly wasted. Trophic changes: A

large scar was found on the ulnar edge of the hand. He said it was due to frostbite, eighteen months after the original injury. He had "blisters" on the hand in winter, but not in summer. Skin: Smooth, atrophied, and glossy. Fourth and fifth digits slender and tapering. Hair: Short, stumpy, and brittle over the first phalanx of the fifth finger. Nails normal. He says this part of his hand never sweated in the hottest weather, and, it being a warm day, I found the ulnar half of the hand drier and colder than the rest. Sensation: Absolutely no sensation of touch, heat, or temperature; neither could he feel moderately firm friction on the fifth finger. Fourth finger: Slight tactile sensation at the tip of the ulnar half, but he could not tell what part of the hand was being touched. No sensation of pain or temperature whatever. The inner side of the palm was quite anæsthetic, especially over the large scar of the frostbite. His hand was altogether very useless; the only thing he could do to earn his living was to work a mangle.

A consideration of these cases leaves no doubt that division of the ulnar results in a very serious loss of power and usefulness in the hand, and that such an accident should be looked upon as one of considerable gravity to a patient in almost any class of life.

Symptoms of Division of the Median Nerve.—The median nerve is divided very nearly as frequently as is the ulnar. The most common seat of injury is immediately above the wrist-joint, where the nerve is somewhat superficial. This nerve may in addition be wounded in almost any part of the rest of its course, most frequently immediately above the elbow.

The muscles paralysed will depend upon the seat of section. If high up in the upper arm, all the flexors and pronators arising from the condyles of the humerus and the bones of the forearm will be affected, with the exception of the flexor carpi ulnaris and one-half of the flexor profundus digitorum. The muscles of the ball of the thumb, except the abductor and one-half of the flexor brevis pollicis, will be likewise paralysed, also the two outer lumbricales.

As a result of this loss of power, flexion, pronation and supination of the forearm are weakened, but are not entirely absent.

A certain amount of flexion at the wrist is rendered possible by the immunity of the flexor carpi ulnaris. Pronation is very feeble, and is only accomplished by allowing the weight of the hand to



Fig. 17.

FIG. 17.

The palmar surface of a hand some months after section of the median nerve. It shows the wasting of the thenar muscles and the area of anæsthesia. The darkness of the shading indicates the amount of the anæsthesia.



rotate the arm back to its former position after supination has been accomplished by the biceps and the special supinators.

On account of the paralysis of the flexor longus pollicis, the terminal phalanx of the thumb cannot be flexed. Such is not the case with the proximal phalanx, which is bent and adducted by the muscles supplied by the ulnar nerve. But as regards the movements of the thumb, the most important loss of power, and that which is most typical of section of the median, is due to paralysis of the opponens pollicis. In all cases of accidents to the median nerve, the failure which follows the most strenuous efforts of the patient to abduct or oppose the thumb points at once to the seat of the mischief, the only result of all attempts being a flexion and adduction of the first phalanx, and a slight dragging on the metacarpal bone.

The paralysis of the flexors of the index and middle fingers results in a failure to flex the second and third phalanges, the first phalanx being bent by the unimpaired interossei. Flexion of the fourth and fifth digits is weakened on account of paralysis of the flexor sublimis digitorum.

The grasp of the hand is enfeebled, more especially in the radial half, and the patient cannot hold any small object between the tips of the fingers and thumb.

Of course, in cases where the section occurs at the level of the wrist many of the above-mentioned muscles escape, and flexion of the phalanges of the digits and thumb remains possible, though the typical failure to *oppose* the thumb yet remains.

The deformity resulting in cases where the nerve lesion is of some standing is very typical. The forearm is greatly atrophied, but such healthy muscles as exist on the ulnar half stand out in strong relief. The wrist is bent towards the ulnar side, and is frequently hyper-extended, though not to any great extent. The rounded prominence formed by the ball of the thumb has disappeared, and the metacarpal bone, especially the head, is bare and prominent. In some cases the thumb is drawn backwards by its extensors, and rotated out a little, so that its palmar surface presents more than is natural; this, however, does not always occur.

In most cases the fingers remain fairly straight, and are not bent into the palm, as in the case of division of the ulnar; this is due to the extensors preventing any tendency to displacement by the atrophy of the long flexors. Occasionally, however, when the

hand has been long kept at rest, and the fingers consequently have remained in a state of flexion, the atrophy of the flexors fixes the digits in their abnormal position, and subsequent efforts at extension do not avail to remove the deformity.

Loss of Sensation after Division of the Median Nerve.—The parts in which sensation is either diminished or lost after division of the median are the palmar surfaces of the thumb, index and middle fingers, and the radial half of the ring, also the radial half of the palm, excepting a small portion of the ball of the thumb, which is supplied by the external cutaneous nerve. On the back of the fingers also there is loss of sensory power, and those anatomical descriptions which ascribe to the radial nerve the power to convey sensations from the entire dorsal surface of three and a half digits are disproved by clinical evidence.

There can be no doubt whatever that after section of the median nerve there is loss of sensation over the dorsal surfaces of both the second and third phalanges of the index, middle, and half the ring finger, also over the same surface of the tip of the last phalanx of the thumb, around the nails; sometimes, in addition, the sensation is also distinctly impaired over the back of the first phalanges of index and middle. I have said there can be no doubt on this point, and on this I would rather insist, for the same observation has been made by the most careful investigators. Hutchinson has pointed out this fact in the cases already referred to, published by him in the *London Hospital Reports*, many years ago, and Létiévant has demonstrated and illustrated the same. In all the cases I have investigated, without a single exception, there has been loss of sensation over the dorsal surface as above described, and a failure to recognize the real nerve-supply of the digits not only tends to keep alive erroneous doctrines, but may also lead to mistakes in diagnosis and treatment.

As in the case of ulnar paralysis, the amount of loss of sensation differs in different parts of the anæsthetic area. I have found it greatest at the tips of the index and middle fingers, both back and front, next along the palmar surface of the same, and on the backs of the second phalanges, and least along the face of the thumb and palm; this, of course, is liable to variation. The extent to which supplementary sensation may be present also varies, in some cases it is very marked, in others it is entirely absent; the remarks I have made relating to this subject, in treating of ulnar paralysis, holds good for cases of median division.

FIG. 18.

The dorsal surface of a hand after section of the median nerve, showing the area of anæsthesia.

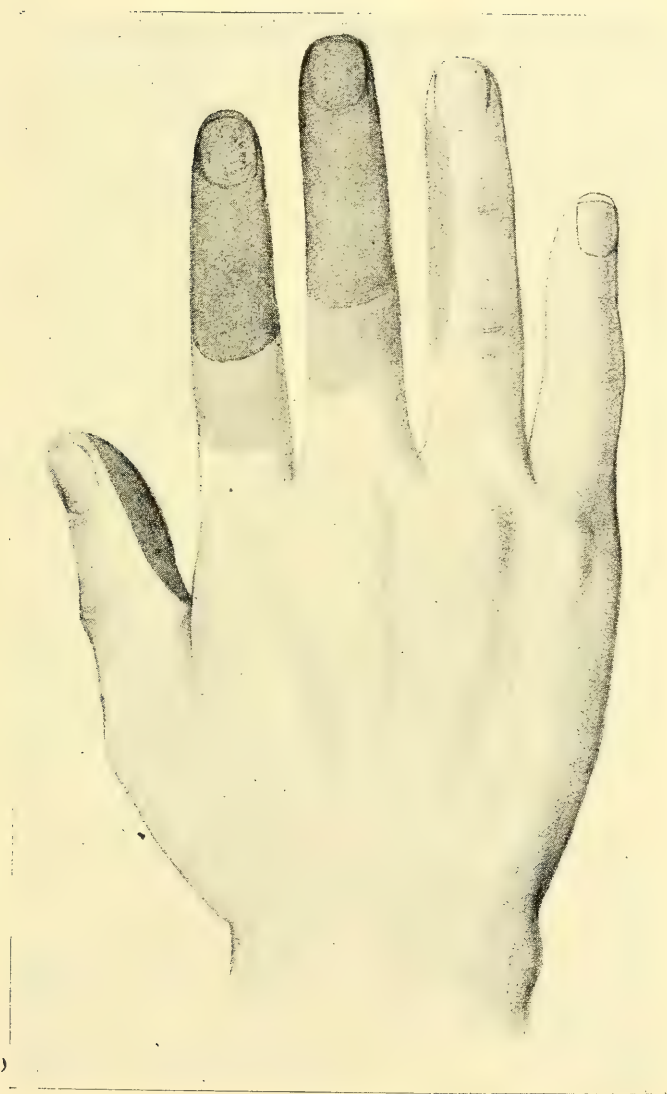


Fig. 18.

The following cases tend to illustrate most of the above points:

W. S., aged thirty-two, was admitted into St. Bartholomew's Hospital on August 3, 1870. He had thrust his hand through a window, and had divided his ulnar artery and median nerve on the front of the forearm, as well as some of the flexor tendons. Nearly twelve years after the accident I examined his hand, and found its condition to be as follows: Scar about two inches above the wrist, closely adherent to the deeper structures; pressure over the course of the median nerve at this spot causes shooting pains in the index and middle fingers. He can flex the wrist, but not forcibly. Has good flexion of the first phalanges of all the fingers, but none at all of the second and third phalanges of the index and middle. The joints of these latter phalanges are very stiff, partially ankylosed, and admit of but slight movement even on the application of considerable force. He can flex and abduct the thumb well, but has no power of opposition, and cannot pick up a pin. The power of grasp is very weak. The radial side of the hand is considerably thinned, and the ball of the thumb much flattened, the fingers are straight and show no tendency to become flexed into the palm. Trophic: Index and middle fingers very much colder than rest of hand, thumb in similar condition, but loss of temperature not so great. Skin over back and front of the two last phalanges of the index and middle fingers red, glazed, and tightly stretched, so that it cannot be pinched up. A similar condition, though less marked, prevails over the first phalanges of the same fingers, especially on their palmar surface, but is also noticeable on the dorsum as well. These fingers are thin and tapering. Radial side of ring-finger similarly affected. Nails normal, says they grow as fast on this hand as the other. Hair entirely absent from back of first and second phalanges of index and middle, also from first phalanx of thumb. Secretion: Is quite sure that the index and middle fingers never perspire; at the present time they are dry, while the rest of the hand is moist. In winter and in wet weather, but not at other times, he suffers much pain in the index and middle fingers. Sensation: He can localize tactile sensations over the two last phalanges of the index and middle fingers, back and front. Sensation is, however, much impaired, and he cannot tell what sort of a body it is that touches him, neither can he distinguish the two

points of a compass even when separated the whole breadth of the finger. On the palmar surface of the first phalanges of the same fingers sensation is but little better, but is improved over the back of the same, so that it is very doubtful if he ever recognized the two points of a compass as such. Tactile sensation much impaired over all palmar surfaces of thumb and back of third phalanx; he can, however, localize fairly accurately. Radial side of ring but little impaired. Sensation of temperature and pain: He has absolutely no sense of temperature or pain in the parts just described, and says he has often blistered his fingers carrying hot plates, without being aware of it. One exception to this statement must be made for the radial side of the palm, where a prick causes slight pain, and is recognized as such, and also for the palmar surface of the first phalanx of the thumb. The patient, who is a very intelligent man, is quite sure that his hand has improved within the last five years, and that before this time he had no sensation at all in either the index or middle; he thinks it is still improving.

There can, I think, be but little doubt that in this patient the nerve ends were not united, and that the little feeling he possessed was due to the gradual development of "supplementary sensation"; his statement to the effect that sensation had considerably improved in the last five years, was very interesting in regard to this point.

The muscles supplied by the divided nerves remained absolutely paralysed, and were quite atrophied, there was no sign of any regeneration of the motor nerves. The absence of all pain, combined with the presence of glossy skin, during the space of twelve years, I have already alluded to, with reference to Mitchell's statement that glossy skin was always combined with pain, and was not a permanent condition. The state of the hair and secretion of sweat is also worthy of notice.

One of the most peculiar circumstances in connection with injury of the median nerve is that not only may the nails of the index, middle and thumb show the trophic changes already described, but those of the little and ring fingers also are frequently similarly affected.

It is extremely difficult to account for such a state of things. It is certain that no branch of the median is distributed to the little finger, and the only suggestion I can offer is that the alteration in

the nail of this digit is of a reflex nature. With regard to the ring-finger, an explanation is more easy, for not only is it supplied in part by the median nerve, but in section of this nerve it will be found that almost all the tip of the finger is anæsthetic. I think that the ulnar nerve supplies but little of the pulp and matrix of the nail in the ring-finger.

The following cases may be quoted in support of the above-mentioned peculiarity :—

Paralysis and Trophic Changes in the Distribution of the Median Nerve following on Inflammation of the Hand, for which Incisions were practised.—Anchylosis of the Joints of the Fingers.—Trophic Changes in all the Nails.

T. C., aged fifty-two, was admitted into St. Bartholomew's Hospital, October 29, 1884. Seven months previously he had an attack of cellulitis in the hand and forearm, for which numerous incisions had been made. Since that time the hand had been stiff and crippled, and the thumb, index and middle fingers had been numb. Present condition: Index and middle fingers blue and cold. All the nails, including those of the ring and little fingers, striated, ridged, and furrowed. These nails are new ones, all the others came off six to ten months ago. The parts innervated by the median are partly anæsthetic. The muscles and skin supplied by the ulnar nerve are quite natural. Electrical examination: No reaction of any of the muscles supplied by the median nerve, those supplied by the ulnar are normal. All the finger-joints are stiff, and the fingers are flexed into the palm of the hand.

October 6, 1885.—The hand is worse: the skin of the thumb, index, and middle fingers is blue and cold, and completely anæsthetic. The muscles supplied by the median nerve in the hand are paralysed and wasted. The nails are natural.

R. C., aged seventeen, divided his median nerve on May 17, 1882. The nerve ends were sutured on October 31, at which time the nails of all the fingers, including the little finger and the ring were curved, ridged and furrowed, brittle and fibrous. The thumb-nail was short and stumpy, the old nail having been shed a month previously.

On April 17, 1883, the nerve had to a great extent united, and the nails were in a natural condition.

H. J., aged fifteen, divided his median nerve above the wrist-joint on December 24, 1884; the cut ends were sutured.

July 9, 1885.—The nails of all the fingers, including the ring and little fingers, are coming off, and the new nails are three-parts grown. There is a sharply marked line separating the old nail from the new. The old nails are ridged, fibrous, curved and brittle.

Symptoms of Division of the Radial Nerve.—The radial nerve is not divided nearly as frequently as are the others which, with it, supply the hand. Neither is its section followed by such serious consequences as ensue on division of the median and ulnar, for, as it merely acts as a centripetal nerve, the paralysis and deformity so characteristic of section of these trunks is absent.

The following case supplies further proof, if this indeed is necessary, that the median innervates the skin over the dorsal surfaces of the second and third phalanges of the index and middle fingers:—

J. I., admitted into St. Bartholomew's Hospital, on April 3, 1875. He has a deep wound over the back of the right wrist, dividing some of the extensor tendons and the branches of the radial nerve which supply the index and middle fingers.

June 3rd.—Sensation is completely lost over a small area, including the back of the first and second metacarpal bones, and of the thumb but not on the dorsal surfaces of the fingers.

Symptoms of Injury to the Musculo-spiral Nerve.—This nerve may be injured either by open wounds or by fracture of the humerus. The *muscles* paralysed in such an injury comprise all the extensors of the forearm and wrist, as well as the supinators. The patient is thus unable to extend the elbow, the hand hangs in a position of flexion, the wrist drops, and the fingers are flexed at their distal joints. Extension of the latter is, however, possible when the proximal phalanges are flexed. This is due to the action of the interossei and lumbricales, whose office it is to flex the metacarpo-phalangeal joints, and extend those of the last two phalanges.

Supination is not entirely absent, for the biceps muscle, whose innervation is yet intact, is able to rotate the forearm outwards as well as to flex it; the movement, however, is of course much weaker than is natural.

The deformity that subsequently results in cases where the

division of the musculo-spiral is of some standing, consists of extreme atrophy of the extensor muscles, with permanent flexion of the wrist and fingers, due to the unbalanced action of the flexor muscles. The atrophied muscles do not cause hyper-extension as would be the case if their contraction was of an active character.

Loss of Sensation after Division of the Musculo-spiral.—If the nerve has been divided above the origin of its cutaneous branches, there will be loss of sensation over the outer part of the arm in about one-fourth of its circumference, extending from the insertion of the deltoid to the external condyle. On the forearm, the radial side of the dorsum in the upper two-thirds is anæsthetic, whilst in the lower third the area of anæsthesia is much more limited, and includes a narrow portion of skin in a line with the metacarpal bones of the thumb and index finger. On the hand, the dorsal surface of all the thumb is anæsthetic, but occasionally there is slight preservation of sensation around the nail; the skin covering the dorsal surface of the metacarpal bones of the thumb, index and middle fingers, as well as the lower parts of the first phalanges of the same fingers, is in a similar condition.

Simultaneous Injury of several Nerves of the Upper Extremity.—It is by no means uncommon for two of the nerves of the forearm to be divided by one and the same accident, those most commonly implicated being the median and ulnar. Several such cases have been described by Hutchinson, in the *London Hospital Reports* already referred to. The symptoms special to such accidents need not be described in detail, for they may be easily deduced from a consideration of those due to section of the same nerves separately. The following case is fairly typical.

John G., aged fourteen, was admitted into St. Bartholomew's Hospital, on November 9, 1881. He had sustained a very severe wound from a circular saw, which had divided the whole of the structures lying across the front of the wrist, including the ulnar and median nerves, the wrist-joint was opened, and the ulna cut nearly in two. The nerve ends were sutured together with catgut, and the wound healed slowly; there was, however, no return of motion or sensation.

On August 19, 1882, I examined the hand and found it in the following state:—Deep scar about one inch and a half above the wrist, adherent to the ulna, and not painful or tender. Wrist-

joint ankylosed; can scarcely move the fingers in the least, thumb very slightly movable. The hand is very flat and thin, all the muscles supplied by the ulnar nerve are extremely wasted, as are also to a less extent those forming the ball of the thumb. The metacarpo-phalangeal joints are hyper-extended, and those of the two distal phalanges much flexed, so that the hand possesses the typical claw shape; it is quite impossible to straighten the fingers; the thumb is not contracted. Trophic changes: Skin over front of palm smooth and glazed, also on the palmar surface of the fingers, though this is not universal. The backs of the little and ring fingers are smooth and shining, but rather pale in colour. Towards the tips of the dorsal surfaces of the index and middle, the skin is slightly glazed, but over the first phalanges is normal, as well as on the back of the hand. There is scarcely any hair on the dorsum of the first phalanx of the thumb, and none at all in the same situation on the other digits; the orifices of the hair follicles may be seen as small black dots; the other hand is hairy in the above situations. The nails of the fingers are very striking, being short, stumpy and broken, exceedingly arched, both longitudinally and transversely, with transverse furrows and ridges running across them, the latter being marked with a delicate longitudinal striation, giving them a "toothed" appearance. Eight months ago the nail of the little finger came off without any previous pain, and the new nail is very small and ill-formed. The thumb nail is normal; he says they all grow as quickly as do those on the other hand. (I have already referred to this case in describing trophic changes in nails.) He thinks one hand sweats as much as the other. Sensation: Very imperfect over the whole palm; he can with difficulty localize sensations, but cannot distinguish the two points of a compass, even one inch apart. No sense of pain or temperature. The palmar surfaces of the thumb, index and middle fingers are in a similar condition, the ring-finger is very insensitive, and the little one quite anæsthetic. On the back of the index and middle fingers he can localize with difficulty at the tips, but has no other sensation. Over the middle phalanges he can distinguish two points a quarter of an inch apart; sensation over the first phalanx is normal. The dorsal surfaces of the fourth and fifth digits are in the same state as the palmar. The dorsal surface of the thumb is nearly normal, there being but slight impairment of sensation at the tip.

October 19th.—No material change. The trophic changes in the hair over the back of the first phalanges, and the changes in the nails, combined with loss of sensation over the dorsal surfaces of the index and middle fingers, afford very strong evidence of the influence exercised by the median nerve over both the sensory and trophic functions of the skin and cutaneous appendages on the backs of these digits. (The further progress of this case will be found in the chapter on Treatment.)

In considering the symptoms which follow section of any of the nerve-trunks of the upper extremity, it is most important to remember that some of them may be due to wounds inflicted on the neighbouring tendons. From their very situation it is very difficult to divide the median or ulnar nerves, and at the same time avoid wounding the contiguous structures, so that the subsequent loss of motion and deformity is often caused by section of some of the many tendons. It is frequently most difficult to separate the symptoms of the nerve-injury from those caused by such other damage, and much care is requisite before arriving at any definite conclusions on this point.

Rupture of the Brachial Plexus.—In addition to section of one or several nerve-trunks, it occasionally happens that either all or some of the nerves forming the brachial plexus may be torn across. This accident most commonly occurs in cases of dislocation or severe wrenches of the shoulder.

Both Hutchinson * and Mitchell Banks have, however, recorded instances of this injury following a fall on the shoulder, without luxation or fracture; while Paget records three cases,† in two of which there was a history of a direct blow on the shoulder, and in the other the arm of a child had been violently wrenched. I shall venture to give these cases in detail, and will briefly refer to the others.

In the case by Hutchinson, the patient came under notice four months after the accident; he was a young sailor, and had fallen heavily upon his shoulder on to the deck.

“The condition of the arm when the man came to me was such as to suggest the diagnosis of rupture of the four lower roots of the brachial plexus. With the exception of the triceps, brachialis

* *Path. Soc. Trans.*, vol. xxxi. p. 27.

† *Med. Times and Gaz.*, March 1862.

anticus and coraco-brachialis, the muscles of the upper extremity were wholly paralysed. The deltoid was also quite paralysed, as also the latissimus dorsi, and the lower part of the great pectoral, whilst the upper part of the latter and the rotators of the humerus arising from the scapula had escaped, the forearm and hand being helpless, but the elbow could be flexed and the forearm supinated. There was no sensation below the elbow, and it was very defective over most of the upper arm and deltoid region." The muscles were wasted, the hand cold, and there were no lesions of nutrition. The pupil of the eye on the injured side remained contracted under circumstances which caused its fellow to dilate, the eyeball was slightly retracted and appeared small, while the palpebral fissure was distinctly narrowed.

Another case is recorded by the same author in vol. i. of his *Illustrations of Clinical Surgery*. The patient was a man aged forty-two, who five months previously had fallen very heavily on his shoulder (left side). The arm and forearm were much wasted, and entirely powerless, as were also the pectoral muscles, the latissimus dorsi, the rhomboidei, and the supra and infra spinatus; the trapezius and levator anguli scapulæ acted well. Sensation: None in forearm, or on the outer, anterior, and posterior surfaces of the upper arm; in the axilla and part of inner side of arm it was normal. The front of the shoulder and outer half of the supra-spinous fossa were insensitive, while the back of the same joint and the space between the spine, the scapula and the vertebræ, maintained their natural sensibility. The whole limb was cold and the skin thickened by œdema, the ear also felt less hot than its fellow, the sight of the eye was impaired, and the pupil did not dilate to the same extent as that on the opposite side. After six years the patient could flex the elbow by means of the biceps, and had sensation over the first and second metacarpal bones.

Mr. Banks's patient* was a sailor, aged thirty, who fell on his shoulder down the hatchway, about a couple of months before coming under notice. There was "complete loss of sensation in the hand and back of the forearm, and in the upper arm. Complete loss of motion from the shoulder downwards. Wasting of muscles of shoulder and upper arm. No pulse in the

* *Trans. of Int. Med. Congress*, 1881, vol. ii. p. 443.

radial, ulnar, brachial or axillary arteries." The deltoid alone reacted to faradism, and the great pectoral very slightly. An exploratory operation revealed that "the plexus had been torn away bodily from the spinal column, and had been dragged downwards below the clavicle," with the exception of one small cord which appeared to supply the deltoid and pectoralis major. The axillary artery had been injured, and was found obliterated. No mention is made of the state of the eye.

In a case which I have recently seen, paralysis of motion and sensation in the entire upper extremity resulted from a severe blow on the shoulder by the buffer of an engine, which, in addition, fractured the upper extremity of the humerus and the clavicle. The patient said that all feeling and motion had gone from the arm when he was aroused from the state of insensibility caused by the accident, and six months later, when he came under notice, there was considerable atrophy of all the muscles of the forearm and arm, as well as those of the scapular region; there were no signs referable to injury of the sympathetic, and the pupils were normal and equal. None of the affected muscles reacted to faradism. Under the impression that the axillary nerves might have been torn, they were freely exposed in the axilla, but were found to be intact.

Le Bret* records a very typical case of rupture of the brachial plexus in a young soldier, aged twenty-two. The humerus had been dislocated twenty-four hours, when reduction was effected by means of pulleys, and was followed by immediate paralysis, with a sense of sudden laceration of something in the clavicular region. Five months later, Le Bret found loss of sensation from the shoulder to the finger-tips, with complete paralysis of the whole upper extremity, a portion of the neck on the same side was anæsthetic; the arm was cold, and the muscles atrophied. There was slight movement in the scapular muscles. The iris did not dilate so widely as that of the opposite side, and sight was impaired.

Four cases of similar symptoms, following on reduction of dislocations of the humerus are recorded by Flaubert.†

* *Mem. de la Soc. de Physiologie de Paris*, 1853, p. 119.

† *Rep. Gen. d'Anatomie et de Physiologie Pathologique*, 1827, p. 55.

i. A woman, aged fifty-four, had dislocated her shoulder three weeks previously. Reduction was effected by extension, and was immediately followed by hemiplegia, the leg as well as the arm being paralysed. The eye of the same side was at first slightly closed, but subsequently became normal. The forearm rapidly wasted, was cold, numb, and tingling, all movements in it were much weakened, and sensation was abolished in the fourth and fifth digits, but not elsewhere. The leg recovered in three months.

ii. A woman, aged sixty-six, had dislocated her shoulder five weeks previously. Reduction was effected on December 8th, and immediate paralysis resulted; the patient became insensible, and suffered from severe headache. On the 11th it was noted that the pupil was more contracted than its fellow, and did not act to light. The amount of sensation in the limb appears to have been doubtful.

On December 26th the patient died, and at the post-mortem examination the following condition was found: The four last nerves of the brachial plexus had been torn away from their attachments to the spinal cord, and were found "bound together at the level of the axilla by fibrous tissue;" the ganglia on the posterior roots were attached to the torn nerves.

iii. A woman, aged sixty-five, had dislocated her shoulder twenty-seven days before coming under notice. Reduction was followed by immediate loss of sensation and motion; no mention is made of the condition of the eye.

iv. A man, aged fifty. Dislocation fifteen days previously. Similar symptoms.

Desault * records two similar cases, though not apparently of so great severity.

The following is the description given by Paget of the cases under his care:—

"In the first the patient was a man, aged twenty-three, who had met with an accident by falling out of a cart five weeks before he came under notice. He was stunned and remained insensible for fifteen or sixteen hours. When he recovered he

* *Œuvres Comp.*, vol. i. p. 335.

found the arm completely useless, and in spite of galvanism, friction, and rest, it rapidly wasted. He looks well, and feels in perfect health. His left arm hangs heavily in his other hand; he has absolutely no power in it, and can only lift his shoulder. On his thumb and forefinger are two sluggish ulcers, the result of his holding his hands closely to a fire without feeling it too hot. The upper arm is very flabby and wasted, the forearm the same, though in a less marked degree; it feels slightly warmer than its fellow. He has no sense of temperature, and does not know whether his finger is dipped into hot or cold water. The limb is rather duskier than the opposite arm, but there is no sensible difference in the pulse on either side. Sensation is better in the upper and inner part of the upper arm than in any other portion of the limb, perhaps from the intercosto-humeral nerves being unaffected, but there is also some sensibility in the outer part of the upper arm. The left pupil is smaller than the right, but both act equally well, and there is no defect of sight in either eye. The condition of this man's arm must be ascribed, I believe, to some injury of the brachial nerves, probably, though it is not evident how it happened, to an injury of the brachial plexus at the base of the neck or in the axilla. Such concussion as he suffered is not at all likely to have caused complete paralysis of one arm without any other symptoms of injury to the brain or spinal marrow; and the character of the paralysis, its completeness, the coldness of the limb, its wasting, and the occasional severe pain, and the sloughing of the skin after moderate heating, are just like the consequences of division, or great damage of the nerve-trunks.

“Nearly all these things have been observed in two other cases I have seen. In one of them (a little girl about seven years old), a ladder fell on the back of the left shoulder, and then broke her leg. The exact manner of its fall was not known, but the integuments over the scapula and by the side of the neck were scarcely bruised. She was stunned and unconscious for less than ten minutes, and then perfectly recovered her senses. As soon as she had recovered from the shock, she called out ‘Where’s my arm?’ and from that moment to the time at which I first saw her (about four months after the accident) there had been perfect insensibility of the arm. It had been for a time painful subjectively, and there were some kinds of contact which distressed her, but she could

feel no common touch, no heat or cold, and had only morbid sensations either spontaneously or from some irritation. There had been also total loss of motion in the arm till within a month before I saw her, when the pectoral and posterior scapular muscles had regained slight power. Every part of the arm had greatly wasted, and it was habitually cold, with slight swelling and congestion of the hand.

“Some years ago, I was consulted about a little boy, nine or ten years old, whose left arm, when he was an infant, was violently pulled by a little brother, and from that period for a long time appeared powerless. But he had gradually gained some use of it, and when I saw him could move it in any way, and was fond of climbing with it. It was, however, comparatively very weak, and was small like one extremely emaciated. It was not short, but altogether not more than two-thirds the size of the other.

“The inequality of the pupils is well marked in the man now in Darker Ward. The pupil on the injured side is always smaller than the other, but they both act equally well, and there is no defective sight. The same condition has existed ever since the injury in the young lady whose case I related next after his. Her right pupil corresponding with the paralysed right arm, is always smaller than the left, and there is a very slight appearance, which is said to be increased when she is not in perfect health, as if the right eye was a little smaller, or less open than the left.”

The next case is one recorded by Dr. Ross.

Ross.—Rupture of Brachial Plexus.

The patient was a young man, aged nineteen, whose left arm had been caught nine months previously by the strap of a revolving wheel. He was lifted from the ground by the entangled arm, and was stunned. On recovering consciousness it was found that his left arm was completely paralysed. Nine months after the accident it was found that all the muscles of the hand, forearm and arm, as well as the sternal portion of the pectoralis major, were completely paralysed and atrophied. The clavicular portion of the pectoralis major, the pectoralis minor, the external and internal rotators of the humerus and the latissimus dorsi, were spared, while the serratus magnus on the left side was enfeebled but not paralysed. The skin of the inner, of the upper two-

thirds, of the anterior, of the whole of the outer, and of the whole of the posterior surfaces of the arm was nearly as sensitive on the left as on the right side, and the sensitive area extended posteriorly to one and a half inches below the elbow, and there was complete anæsthesia of every form of cutaneous sensibility below the specified areas. Sensibility was supplied to the inner surface of the arm most probably by the intercosto-humeral nerve, and to the remaining sensitive areas of the arm by the cervical plexuses and the communicating branch from the fourth nerve to the brachial plexus. The patient also manifested, on the left side, comparative contraction of the pupil, diminished palpebral aperture, flattening of the cornea, diminution of the intra-ocular pressure, and, five months after the injury, a slight relative increase of temperature in the left external auditory meatus.*

The following case, by Leflaire, is another example of a similar injury:—

Leflaire.†—Rupture of Brachial Plexus.

A man, aged thirty, was struck on his left shoulder by a large piece of wood, which fell from a height with such force that it threw him on the ground in an unconscious condition. In addition to a fracture of the ribs, with laceration of the lung and a scalp wound, the patient had complete paralysis of the left arm, with absolute anæsthesia, except in the region supplied by the intercosto-humeral nerve. The left pupil was contracted and fixed. Eight days after the accident the biceps alone contracted—and then feebly—to the interrupted current. The muscles of the forearm no longer contracted. Four months later there was no improvement; the pupil remained contracted, and trophic changes commenced in the hand.

A case exactly similar to the preceding was recently shown at the Clinical Society by Mr. Charters Symonds. The patient, a young and healthy man, had met with a severe injury at sea, and from that time the arm had remained paralysed completely. As the limb was a perfectly useless appendage, amputation was performed.

I have seen another case at St. Thomas's Hospital, under Dr,

* *British Medical Journal*, May 5, 1883, p. 868.

† *L'Union Med.*, 1884, vol. xxxviii. p. 397.

Hadden, and in it also the conditions described above were well marked, as well as in a case recorded by Mr. Morrison.*

There can be little doubt that in all these cases a nearly identical lesion was present, for in all the symptoms were remarkably similar, and in two of them a post-mortem examination showed that the nerves had been torn from their attachments to the spinal cord. I have said that it is probable that a *nearly* identical lesion was present, for it seems very likely that in some the cords were themselves stretched or torn, and not wrenched from their insertion into the cord. There would result a corresponding difference in symptoms, which may be explained as follows:—In many cases an abnormal condition of the eye was noticed, and, as will presently be shown, this condition is similar to that which results from injury to the sympathetic trunk in the neck. But this trunk receives its branches from the cilio-spinal centre in the cord through the communications with the anterior roots of the spinal nerves, so that when these are torn from the cord itself the connection between the eye and cilio-spinal centre is broken, and the above detailed symptoms ensue. This would not be the case when the nerve-trunks themselves were torn, and thus the exact seat of the injury may be further localized. In one of Mr. Hutchinson's cases it is noted that the ear on the affected side was the colder of the two. This also was probably due to lesion of the sympathetic.

The case by Flaubert, in which the leg also was paralysed, differs in this respect from all the others. I should suppose that this was probably due to a coincident lesion of the spinal cord.

Symptoms of Division of the Sciatic Nerve.—The nerves of the lower extremity are by no means so frequently injured as those of the arm, partly because the leg is not exposed to that class of injuries already described, by which the nerve trunks of the upper extremity are most frequently damaged, and partly because they are on the whole deeper beneath the surface.

I have described in another chapter how the nerves of the leg may be damaged in fractures, and will now only briefly allude to the symptoms of injury of the sciatic trunk in the thigh.

In most cases of this injury the nerve is divided below the origin of its muscular branches to the hamstrings, and as the extensor muscles of the thigh are supplied from a different source, the limb

* *British Medical Journal*, 1887, vol. i. p. 1044.

retains its mobility on the trunk. In the leg, however, the case is different, and the whole of the muscles below the knee and of the foot are paralysed. Nevertheless, in spite of this, the patient is able to walk to a certain extent; he is in fact in much the same condition as many children with infantile paralysis, who yet manage to progress wonderfully well after the following manner.

The leg is extended upon the thigh and thrown forward with a jerk by the action of the quadriceps extensor, while the thigh is flexed on the trunk by the psoas and iliacus. The toes generally come first to the ground, and then, as the weight of the body is brought forward by propulsion due to the power of the healthy limb, the heel is pressed downwards and the weight of the body rests on the injured leg. In order that the patient should progress with any security, it is necessary that this weight should be transmitted through a line passing immediately down the long axis of the limb, for the ankle and foot are liable to splay if any lateral pressure is brought to bear; the knee therefore is kept steady by the semi-tendinosus, gracilis, and sartorius on its inner side, and by the quadriceps extensor in front.

The body is thus supported during the brief interval necessary for the sound leg to swing past and reach the ground—an interval which is shorter than natural, for the steps taken by the injured limb are very short. The paralysed leg is then flexed at the knee by the semi-membranosus and biceps and again brought forward as before, the foot generally hanging down and the toes dragging. The whole movement is thus due to the unparalysed muscles of the thigh, for, as Létievant has well put it, the leg bears much the same relation to the patient as does an artificial limb.

The loss of sensation does not appear to be nearly so great as might have been expected. The only author who appears to have investigated this subject with any accuracy is Létievant,* and according to him the foot and outer part of the leg are the only absolutely anæsthetic parts. He points out that the long saphenous nerve and the small sciatic supply a considerable portion of the leg, and the rest of the sensation he attributes to the anastomoses of the small sciatic with the cutaneous branches of the paralysed trunk.

For further information on this subject I would refer to the cases described by this author, and to one by Paget in the *Medical Times and Gazette* for March 26, 1864. In the latter the patient had

* *Op. cit.*, p. 147.

been dragged by his foot caught in the stirrup three years before coming under notice. "Since that time he had had partial paralysis of the right limb, lately rather increasing. He dragged the limb after him, but it was little, if at all, wasted, and the muscles of the thigh acted moderately well."

Injuries of Nerves in the Neck.—Almost any of the nerves in the neck may be injured, though some are more frequently wounded than others. Wounds of the superficial cutaneous branches present no symptoms of sufficient importance to merit special attention. The motor branches—namely, the descendens noni and the spinal accessory—may also be divided either by accident, or, in the case of the latter, by the surgeon in cases of wry-neck. I have no knowledge of any injury to the former nerve, but various instances of the latter may be found recorded; the symptoms are such as might be expected, and consist of paralysis and atrophy of the supplied muscles.

Division of the phrenic is a very rare accident, and is supposed to result in congestion of the base of the corresponding lung, on account of paralysis of the diaphragm.

Injuries to the hypoglossal nerve are not of frequent occurrence. They result in loss of power of that half of the tongue to which the nerve is distributed, with protrusion to the injured side, a soft flabby feel of the affected half with subsequent atrophy, and some difficulty in deglutition and speech.

One such case is recorded by Mr. Hutchinson, as the result of a stab in the neck.* Another is described by Mitchell,† in which the injury was caused by a gunshot wound. I have myself seen this nerve divided in a case of cut-throat in an elderly man without any other very serious lesion accompanying it, but a month later the paralysed half of the tongue was flabby, and it was protruded towards the paralysed side.

The following case by Cameron is of interest in connection with this subject.

Cameron.—Stab in the Neck, by which the right Hypoglossal Nerve was divided.

The patient was a woman who had been stabbed by her husband. In addition to other wounds there was one situated a little below the angle of the jaw on the right side, and, so far as

* *Med. Times and Gaz.*, April 13, 1872.

† *Op. cit.*

the incision of the skin was concerned, seemed little more than a harmless puncture. From the very first, however, it was noticed that the patient's utterance was slow and thick, like that of a person intoxicated. A further examination showed that there was a paralytic condition of the tongue, which could only be attributed to a wound of the hypoglossal nerve. Three weeks later the following note was made:—Tongue protruded very materially to the right side, the deviation extending even to the tip. The right side of the tongue has a flabby appearance, and assumes two or three transverse wrinkles, due apparently to the flabby state of the muscle. It can be moved in all directions, although imperfectly and with difficulty to the left. When protruded the tip can be applied pretty well to the upper and lower lips, and it can also be hollowed into a groove. The tactile sense is perfect, and the sense of taste for sweet, acid, and bitter seemed almost perfect. There was no paralysis of the soft palate. The patient seems to have some difficulty in disposing of the saliva at the back of the mouth. No deviation can be detected in the position of the hyoid bone nor any special furring of the tongue. She died on April 9th, and the post-mortem examination showed a division of the right hypoglossal nerve just internal to the bifurcation of the carotid artery. The cut ends were retracted and the proximal end was bulbous. On microscopic examination of the distal end of the cut nerve it was found to be in a state of advanced fatty degeneration, and the muscles of that half of the tongue supplied by the cut nerve were in a similar condition.*

Injury of the Sympathetic in the Neck.—The records of cases of injury to this nerve are necessarily few, but the symptoms which have been noticed are of much interest. Before considering these symptoms, I shall briefly allude to the principal facts described in the few cases I have been able to consult.

Mitchell, Moorhouse, and Keen† describe the condition of a young soldier, aged twenty-four, who was shot through the neck in such a direction that the cervical sympathetic might well have been wounded; the symptoms coincided with such as Mitchell subsequently describes as characteristic of injury of this trunk, and were yet present two years after the wound was inflicted. Three months later it is noted—"He was able to

* *Lancet*, 1884, vol. i. p. 885.

† *Gunshot Injuries of Nerves*, p. 39. (Also referred to by Mitchell, *op. cit.*, p. 318.

return to duty . . . nearly all his peculiar symptoms having disappeared."

In another case by Mitchell,* a captain was shot in the neck, but in such a position as to lead the author to think that the sympathetic could not have been injured, though the symptoms were nevertheless characteristic of this lesion and existed two years after the accident.

Dr. William Ogle† details the history of a patient in whom, after a deep-seated abscess in the neck, symptoms of injury to the sympathetic supervened, presumably from implication of the trunk in the process of suppuration.

Dr. J. F. Payne‡ gives a very minute account of the condition of a child, in whom the cervical sympathetic was supposed to have been injured during delivery; the symptoms continued so long as the child was under notice, it was then about two years of age.

Mr. Jonathan Hutchinson§ describes a case in which, after an attempt to commit suicide by cutting her throat, a woman, aged forty-two, developed all the symptoms of injury to the sympathetic.

The most interesting case, however, because the most exact as to the real injury, is one by Mr. T. F. Chavasse.||

The patient was a little girl, aged six years, and was suffering from a tumour in the neck, on the right side. During the operation undertaken for its removal, the pneumogastric and sympathetic nerves were exposed and the latter was probably injured; for the author says, "posteriorly, it was necessary to dissect away the trunk of the sympathetic nerve, as the tumour rested on the transverse processes of the vertebræ." The author believes that only some of the branches, and not the entire nerve-trunk, were divided.

The symptoms observed were nearly identical in all these cases, the differences being so slight as not to necessitate any material difference in classifying them. I shall allude to those points in which the disagreement is the most marked.

The condition of the eye was in all a very remarkable feature.

* *Op. cit.*, p. 321.

† *Med. Chir. Trans.*, vol. lii. p. 51.

‡ *St. Thomas's Hospital Reports*, vol. iii.

§ *Illustrations of Clinical Surgery*, vol. i.

|| *British Medical Journal*, Dec. 17, 1881.

The eyelids were partially closed, and the palpebral fissure narrowed, and in some it was noted that this was rather due to an updrawing of the lower lid than to ptosis of the upper lid, though both were present. In addition, it is noted in the first case by the American surgeons that the "outer angle appears as though it were dropped a little lower than the inner angle. Neither the orbicularis nor levator muscles were paralysed. In all the cases, except that by Mr. Chavasse, the eyeball on the injured side appeared smaller than its fellow, a condition which was due to the sinking of the ball within the socket, a shrinking backwards, and not to a diminution in its diameter.

In two of the cases it was noted that the conjunctiva was increased in vascularity, and in Dr. Payne's case it appeared abnormally dry.

In all five the pupil was in much the same condition. It generally remained slightly more contracted than its fellow, and in Mr. Chavasse's case was as small as a pin's-head directly after the operation. In a bright light the pupils became of much the same size, a condition which was due to a contraction of the same pupil. When the eyes were shaded the unaffected pupil always became the more dilated; in three cases the pupil on the damaged side failed to dilate in the least, and in two—those of Dr. Payne and Mr. Chavasse—it dilated very slightly.

In three of the cases it is noted that the sight of the affected eye was impaired to a greater or less extent, and in two others this might also have been the case; in that recorded by Mr. Hutchinson the patient was only under notice for a few weeks, and in Dr. Payne's the age of the child prevented any satisfactory observations.

In the patients under Dr. Ogle and Dr. Payne, a very unusual dryness of the nostril and mouth on the side of the injury formed a most marked feature. In the captain there was defect of secretion of sweat in the neck, arm, and chest of the injured side, and in the other case recorded by Mitchell there was great difficulty in deglutition and talking after the accident, due apparently to dryness of the mouth.

In neither of the cases under Chavasse or Hutchinson, in which the injury was recent, was there noticed any flushing or hyperæmia, or any anæmia of the face and ear. In three out of the four other cases, the affected half of the face—and it was strictly confined to one side—was in a condition of anæmia, and did not sweat. This

was most marked on exertion, for under the influence of active exercise the healthy side flushed and perspired in a perfectly normal manner, while on the opposite half the skin was dry and pale. Dr. Ogle's patient was induced to take very active exercise in the park, after which the limitation of profuse perspiration to one side was very noticeable. On the side of the face opposite to the lesion, it was sometimes noticed that secretion appeared to be excessive—for instance, the nose and eye watered, and perspiration was profuse and readily induced.

Dr. Ogle offers explanations for most of the symptoms I have detailed, and his accounts are both supplemented and criticised by Dr. Payne. The narrowing of the palpebral fissure is ascribed to the presence of certain smooth muscle fibres which are found in both the upper and lower lids, and are paralysed by the injury. The retraction of the eyeball is considered to be due to the paralysis of a funnel-shaped layer of involuntary muscle (*musculus orbitalis*), which has been shown by Prévost to have the power of causing protrusion of the eyeball, and to be supplied by the sympathetic.

The variation in the pupils is undoubtedly caused by the unbalanced action of the circular muscle of the iris, and the loss of power in the dilator fibres, which are supplied by the injured nerve.

That this is the case is abundantly proved by the absence of the power of active dilatation when the eye was shaded, for it is probable that in the patients of Mr. Chavasse and Dr. Payne the slight dilatation present was the result of a relaxation of the circular fibres, and in the former there might have been in addition some few nerve-fibres left intact to supply the iris.

The impairment of vision I should suppose to be due to the fact that the lenticular ganglion was cut off from its connection with the sympathetic.

The effect of irritation of the sympathetic trunk on the secretion of the submaxillary gland supplies a sufficient basis for believing that the amount of saliva secreted would probably be diminished by its section, and the same might be said with regard to the secretion of sweat, of tears, and of mucus.

Perhaps the most remarkable feature in these cases is that in none of them was there observed any flushing of the face, or neck and ear. In the patients under Hutchinson and Chavasse, the injuries were recent, and yet, while so many other symptoms of

injury to the sympathetic were present, the hyperæmia of the skin noticed in experiments on animals was not present. I cannot offer any satisfactory explanation for this phenomenon. The subsequent anæmic condition of the face is more explicable, for it is only what is found to occur in animals some time after the original lesion, and is due, as I have mentioned elsewhere, to the action of local vaso-motor centres, which, being unconnected with the vaso-motor centre and unable to receive inhibitory impulses, remain in a state of constant action, and keep the vessels permanently constricted.

It only remains to be noticed that in Dr. Payne's case there was present a peculiar shrivelled condition of the skin, of which the author says: "It resembled the skin of old age, or that seen in badly nourished persons, being quite different from the plumpness and crispness of youth and health. This condition may very plausibly be assigned either to want of tone—*i.e.*, paralysis of the smooth muscle-fibres in the skin—or, on the other hand, to a want of crispness and elasticity in the connective tissue of the skin itself and under the skin."

Injuries of the Pneumogastric.—Cases of injury of the pneumogastric are so rare, that it is at present impossible to formulate any class of symptoms as being the invariable sequel to division of this nerve. It is true that analogous cases in animals are to a certain extent instructive, but, in the absence of a sufficient number of instances occurring in the human subject, I shall content myself with referring very briefly to the symptoms noticed in such cases as I have been able to find recorded, and these are but few in number.

In 1849, Chassaignac included the pneumogastric nerve in a ligature passed around the common carotid, and noticed that neither the functions of respiration nor deglutition were in the least disturbed, but that the voice was immediately extinguished. At a recent meeting of the Royal Medical and Chirurgical Society, held on Oct. 27, 1885, Mr. Rivington narrated a case in which he had divided the pneumogastric during the progress of an operation for ligature of the internal carotid. There were no special symptoms, and at the post-mortem examination—the cause of death being a cerebral abscess—no special lesions were found.

The next case, by Mr. Savory, again shows how few may be the symptoms, when this nerve has been destroyed by suppuration.

Writing of the nerve in relation to the abscess, he says: "A large portion of the pneumogastric nerve was also destroyed in its course through the cavity. The two ends of the nerve were found free in the upper and lower part, a portion of the nerve, from one to one and half inch in length, being wanting. . . . Nor was the destruction of the pneumogastric nerve followed by any very obvious effect. During the last two or three days of life the pulse was noted to have been very rapid, but that may be otherwise well explained. The respiration was not remarkably embarrassed, and the left lung after death presented no characters that could be especially associated with the lesion of the nerve, certainly none in striking contrast to the right." *

The next case is not one of injury, but as the pneumogastric trunk was destroyed by pressure, it has some bearing on the symptoms in question.

Riegel.—Death from Pressure on the Pneumogastric by an enlarged Bronchial Gland.

In August 1875, Dr. Riegel recorded the case of a man, aged fifty-three, whose chief symptom was an extreme rapidity of pulse, amounting to 164 beats a minute. This was accompanied by œdema of the bases of the lungs and bronchitis, with slight hoarseness of the voice. The patient died, and a post-mortem examination showed that the left vagus, just below where it gives off the recurrent branch, was matted and embedded in an enlarged bronchial gland. A microscopic examination showed that at this point the nerve had undergone complete degeneration. The rest of the body was healthy.†

The next case is one that was in St. Bartholomew's Hospital. In this patient the whole of the left eighth pair was more or less lacerated by a fracture of the skull, and various symptoms seemed to be distinctly referable to the implication of each nerve-trunk. The condition of the lung found after death is also of interest.

Fracture of the Posterior Fossa of the Base of the Skull, with laceration of the eighth pair of Nerves on the left side.

George M. was admitted into St. Bartholomew's Hospital on Nov. 8, 1884. Whilst drunk he had fallen off an omnibus. He

* *Trans. of Roy. Med. and Chir. Soc.*, vol. lxiv, p. 28.

† *Berlin. Klin. Wochens.*, Aug. 2, 1875; and *L. M. R.*, 1875, p. 617.

was bleeding from the nose and was very sick. The pulse was irregular and quick.

Nov. 9th.—Very restless. He is sensible and can answer questions. Speech is natural. He is continually retching, and has great difficulty in swallowing food. He takes it into his mouth, but is apparently unable to get it into his stomach. He is occasionally sick. He has pain in the back of the head and his head is drawn back. The pulse is 68, and extremely irregular.

11th.—The difficulty in swallowing continues. He is rarely able to take any food into his stomach.

12th.—The patient had a sudden attack of dyspnœa without apparent cause.

13th.—Very restless. Pulse 136. There is spasm of the trapezius muscles and sterno-mastoid. The great difficulty in swallowing continues.

14th.—The patient died. A post-mortem examination showed fracture of the left side of the base of the skull, with laceration of the eighth pair of nerves. The left lung was in a condition of solid œdema and was airless.

In the *British Medical Journal* for June 13, 1866, is recorded a case in which, in a woman aged thirty-six, the right pneumogastric was divided in the wound caused by a suicidal cut throat; there were no marked symptoms and no post-mortem appearances in the lungs.

In the same journal for December 1, 1866, is described the case of a man, aged sixty-eight, in whom paralysis of the eighth pair was followed by very slow respiration and gradual cessation of the heart's action.

It would therefore appear that the results of section of this nerve are not so severe as we might be led to expect from our knowledge of its functions, and it seems probable that the trunk on the opposite side is able to supplement the action of the injured nerve. The present number of cases, however, is not enough to allow of any rules being formulated for human subjects. It has been abundantly proved that in animals section of one pneumogastric is by no means a necessarily fatal injury.

Injury of the Recurrent Laryngeal.—In connection with the subject of injury of the pneumogastric, I shall here allude to

two cases of injury to the recurrent laryngeal. They speak for themselves and require no special comment.

Lefferts.—Wound of Recurrent Laryngeal.

On January 5, 1881, the patient, a strong, healthy German woman, aged forty-seven, was stabbed by her husband in the neck with a long narrow-bladed pair of shears. Turning, in endeavouring to rise, she received a second blow upon the lower jaw, causing a long lacerated wound. On attempting to scream aloud for help she found herself voiceless. "On April 5th I first saw her; she had a long irregular scar on the right side of the lower jaw, a short distance from its angle, and a second smaller one at the inner border of the centre of the mastoid muscle, at the level of the cricoid cartilage."* The patient was completely aphonic, and suffered from slight difficulty of breathing. The laryngoscope showed absolute paralysis of all the muscles of the right vocal chord, it being fixed midway between the extremes of adduction and abduction, and motionless on attempted phonation or respiration. The left cord moved freely.

Liebrecht.—Division of the Recurrent Laryngeal Nerves during the operation of removal of a goitre.

A girl of twenty years of age had a goitre, which was not very movable and not very large. An operation for its removal was undertaken by Mons. Richelot, who tied the four vascular pedicles and removed the gland. The operation was followed by a great deal of asphyxia and difficulty of respiration. The following morning there was found to be aphonia and dyspnœa. At eight o'clock in the evening there was an attack of dyspnœa, in which the patient died. Post-mortem examination showed that the two recurrent laryngeal nerves had been cut, and the upper end of the left recurrent was included in a ligature. The pneumogastric nerves were intact.†

Other cases have also been recorded in which the recurrent laryngeal nerve has been injured in operation on enlarged thyroids.

Injuries to the Facial Nerve.—The facial nerve may be injured in the face, or else, in cases of fracture of the base of the skull, in some parts of its course through the temporal bone.

* *American Journal of Med. Sci.*, vol. lxxxii. p. 155.

† *Révue de Chirurgie*, 1884, p. 1007.

In both cases the ordinary symptoms of facial paralysis supervene, and do not require any detailed account from me. But, in the latter injury, the two petrosal and the chorda tympani are cut off from their central origin, and the additional symptoms include partial paralysis of the pharynx, and perhaps of the soft palate, with asymmetry of the latter. The voice is husky, and deglutition may become difficult, partly on account of the paralysis, and partly on account of failure of secretion of saliva, due to lesion of the chorda tympani nerve.

Several very interesting cases of this class of injury are recorded by Mitchell, and to these I would refer for further information.

Injuries of the Orbital Nerves.—Any one or more of the nerves of the orbit may be injured. It is well known that punctured wounds may result in division of the optic nerve and loss of vision, but as cases of injury to the various motor branches are uncommon, the following history may be of some interest.

J. H., a sailor, was struck by a policeman's truncheon on the left side of the head a fortnight before coming under notice. The blow rendered him insensible, and soon after recovering he found that he saw everything double. He was not much the worse for the injury, and walked from Liverpool to London, where he was admitted into St. Bartholomew's Hospital. He was then found to be suffering from paralysis of the external rectus and superior oblique, with fracture of the orbital process of the malar bone. He remained in the hospital for a month, during which time his paralysis gradually improved, so that when discharged the diplopia was scarcely perceptible. I should suppose that these symptoms were due to pressure on the nerves by extravasation of blood and inflammatory effusion, and not to their laceration.

Wounds of Superficial Nerves.—Our knowledge of the results of wounds of superficial nerves may be traced back to the days of venesection, but though cases of this kind are less frequent than formerly, there is no doubt that they do occur, and therefore merit attention.

The superficial nerves may be injured in any part of the body, but those of the upper extremity are from their situation more exposed, and more frequently suffer.

As these nerves are all of the sensory variety, their complete division is necessarily followed by anæsthesia over a corresponding

skin area, an anæsthesia which, as a rule, rapidly disappears. In most cases there are no other symptoms, either trivial or severe, and the patient rapidly convalesces.

In some few, however—rare exceptions to the rule—a most peculiar train of symptoms supervenes, which may briefly be described as follows. The wound, which in a large majority of cases is a small one, rapidly becomes painful and exceedingly tender, the tenderness spreads for a variable distance along the limb, and is most marked in the course of the wounded nerve. Inflammation and swelling of the lips of the wound may follow, but are not necessary accompaniments. The neighbouring muscles become extremely irritable, and tend to pass into a condition of spasmodic contraction, of either a tonic or clonic character. Any attempt made to flex or extend the limb causes acute pain, and excites the muscles to fresh spasms, which may pass on to general convulsions. This condition may pass away, or become chronic and last an indefinite time; in such cases the health of the patient materially suffers. The wound generally cicatrizes well, but the cicatrix remains as a permanently irritable point, the least excitation of which induces fresh pain and spasm.

Probably the first case described is that by Ambrose Paré, in which such a train of symptoms followed on bleeding the king, Charles IX.

In 1793, Abernethy, in a paper entitled *An Essay on the Ill-consequences of Wounding a Nerve*, drew attention to the same subject. He had not, however, seen a case, but referred to two mentioned by Pott, which were characterized by pain and convulsion, and which, in Pott's opinion, were caused by the nerve being only partly divided.

Swan, in 1834, recorded several cases of injuries to nerves sustained during venesection.* He considered that the symptoms were due to inflammatory action, and says: "I have very little doubt but by far the greatest number of injured nerves in venesection is made troublesome by using the arm too soon and bringing on inflammation, for I have never seen any bad consequences in those patients who have been so ill as to be unable to do anything."

The following cases by the same author are typical of this form of injury, and, as they are seldom seen at present, will bear quotation.

* *A Treatise on Diseases and Injuries of the Nerves.*

"John May, aged twenty-two, applied to me on the 5th of August 1823, with a small wound in the forearm, close to the beginning and on the outer side of the median cephalic vein. It had been produced some days before by an eagle, which struck him with one of his talons. There was not any hæmorrhage at the time of the accident. He complained of much pain up the arm and neck, and very much of his back. He had an inability of moving his arm, except in a trifling degree, and it was so weak that he could not hold any weight in his hand. There was not any inflammation about the wound, and scarcely any swelling. The skin was separated from the fascia a short distance around the wound.

"Aug. 11th.—He said the pain had increased, he felt very weak, he complained of very much tenderness on pressure to some distance round the wound, but when the bit of skin joining the edge of the wound was taken hold of, he complained of very great pain. The pain and tenderness were chiefly on the outside of the biceps muscle, and the external cutaneous nerve appeared to be the most affected, but the internal was also, but in a less degree. He could not sleep. He had leeches applied several times about the elbow, and an evaporating lotion constantly; as his complaints appeared to be increasing, and the edge of the wound so very painful, I took hold of the bit of skin with my thumb and finger nails, and, holding the blade of the scalpel horizontally, removed the circumference of the wound." Within a week the patient was considerably eased, and subsequently improved.

"In a second case, a lady received a cut in the inner side of the first phalanx of the left thumb, followed by a numbness and a sense of fulness, as if the skin would burst; these sensations lasted a fortnight, and the wound healed. Then ensued violent pain with twitchings and spasms all over the body. After six weeks these symptoms gradually subsided, but at the end of seven years the thumb and forefinger remained morbidly sensitive. Lifting a weight, or using the right arm much, always produces sensations as if needles were running into it; and attempting to use the fingers of the left hand, as in knitting, produces giddiness."

In another similar case, in which the injury was in the same locality, the patient, a lady aged twenty-six, suffered in a similar

manner from constant pain and muscular spasms. These subsided rapidly after amputation of the thumb.

In a case related by Sabatier* similar symptoms of pain and twitchings of the leg followed a wound of the long saphenous nerve. The patient very slowly recovered without operative interference.

In the *Medico-Chirurgical Transactions*, vol. xii., Mr. Wardrop gives accounts of several similar injuries. In one, where the symptoms ensued on a wound of the thumb, recovery followed a division of the proximal end of the injured nerve; and in two other cases, where the wound affected the forehead, the same result followed a similar treatment.

Hamilton† also records cases in which a like train of symptoms followed on nerve lesions. The following is the most remarkable. A lady, aged eighteen, having been bled, suffered from severe pain on the second day after the operation. The day following, the arm was swollen and the hand cold and numb. The forearm was flexed on the arm and could not be extended. For the next three or four months the pain and other symptoms continued at intervals, but about then a slight blow on the back of the hand was followed by inflammation of the wrist-joint and an increase of the pain. This was in April 1876, but in July of the same year the thumb and fingers became permanently contracted, and, as a result of constant suffering, the general health failed. By December the pain and spasmodic contraction were worse than ever, and the latter had increased to such a pitch that in spite of an instrument, which by means of a screw tended to open the hand, the nails had become buried in the flesh of the palm, giving rise to a foul ulcer; and, what is also not a little singular, the arm had become covered with hair.

Under these circumstances, Mr. Crampton divided the musculo-cutaneous nerve, and in two or three weeks the tendency to spasm subsided, and the general health improved. Some months later the cicatrix became exceedingly painful and tender, and was removed in August 1877, with the result that the pain in this situation was permanently cured. In 1878, a blow on the wrist was again followed by pain and swelling, with erythema, headache, and general failure of health. Six months later an attack of pneumonia supervened, for which she was salivated; after this all the trouble slowly disappeared, never to return.

* *De la Med. Operatoire.*

† *Op. cit.*

For many years past, such cases seem to have been few and far between, at any rate they are not recorded. I have, however, seen one which was in many respects similar to the above.

In July 1880, I was called to see a woman who had sustained a severe cut on the inner side of the first phalanx of the thumb from a broken soda-water bottle. Cobwebs taken from the coal-cellar had been used to stop the hæmorrhage, and the wound was filled with coal-dust. After clearing away as much of the latter as possible, all bleeding was easily arrested. The wound healed readily, but some weeks later the resulting scar became extremely painful. The pain was of a spasmodic character, and was greatly increased by pressure; the least touch of the scar induced a sudden action of the thumb muscles, so that if she were holding anything in her hand at the time it was immediately dropped. Three months from the time of the first injury I saw her again, and at once noticed a remarkable wasting of the muscles forming the ball of the thumb, so that this was now nearly flat. The scar was exceedingly tender, and pain was referred from it to the tips of the fingers. I recommended excision of the scar, and on this being done a week later all symptoms rapidly subsided. The wasted muscles were to a great extent regenerated, but, nevertheless, a year later were smaller than those of the opposite side.

The symptoms presented by this class of cases appear to be, on the whole, very similar, and I think may be explained. The extreme pain and tenderness, with redness spreading up the arm, noticed during the days immediately following on the injury, are most probably due to an acute inflammation of the damaged nerve.

The later troubles are probably due to several conditions, either singly or combined. In many cases the symptoms seem to point to a chronic neuritis, by which the nerve is kept in a permanently hyperæsthetic condition, and which in its turn induces a similar irritable state of the nervous centres, a combination which is sufficient to account for the exaggerated reflex actions. The frequency with which these cases have occurred in young women, and the concurrence in many of an hysterical condition,* suggests the probability of hysteria playing an important part in the condition of some of the patients. And indeed I think this is almost certainly the case, and must not be lost sight of in considering either the pathology or the treatment. In others it

* *Vide* cases by Swan and Hamilton.

seems certain that the abnormal condition of the nerve spreads to other branches, and the various trophic lesions sometimes noted make this probable. In Hamilton's case there was excessive growth of hair, and I think that the inflammation of the wrist was very probably of a neurotic origin, for its characters were almost exactly the same as those detailed by Mitchell for arthritis depending on nerve lesions. In my own case there was considerable wasting of the muscles of the thumb, possibly due to a chronic neuritis spreading to their nervous filaments; and in others, pain and tingling has been found to follow in digits other than that originally wounded. All these symptoms tend to show a gradual implication of other nerve-branches.

The extremely tender condition of the scar is frequently due to the fact that the subjacent wounded nerve has been caught up in the process of cicatrization, and the constant irritation resulting therefrom may in this way of itself cause exaggerated reflex action and excitation of the centres, or may result in a chronic neuritis.

If, then, the scar which is the source of irritation were removed sufficiently early, we might fairly expect that the trouble which would otherwise result would be checked, and the happy results of such treatment render this view a very probable one.

CHAPTER VIII.

TREATMENT OF CASES OF NERVE SECTION.

Treatment of Nerve Injuries.—For the proper and rational treatment of nerve injuries the first essential is an accurate knowledge of their pathology.

It is to the want of this knowledge that the erroneous theories of nerve union and of the treatment requisite for nerve lesions are to be attributed. To the opinions held on this subject I shall now briefly refer, for they seem to me to be instructive.

The conclusions of Galen, “that nature was powerless to regenerate nerves,” held unlimited sway until the time of Cruikshank and Haighton, and the experiments of these observers, published in the *Philosophical Society's Transactions* for 1795, completely subverted the doctrines taught up to that date. These surgeons experimented on dogs by dividing the pneumogastric nerve on the one side only, and, having kept the animals alive for a varying number of days, they demonstrated that division of the opposite nerve-trunk was not sufficient to cause death, previous experiment having shown that a simultaneous section of both vagi was inevitably fatal. They therefore concluded that the one nerve must have been reunited before the second operation was performed. Swan, Fontana, Descot, and Prévost arrived at the same conclusions, and the result was a very general belief that nerves when divided were *inevitably regenerated*—a belief which led to a corresponding carelessness in the treatment of such injuries, and which has been widely prevalent up till the most recent times, not only in England, but also in France and Germany, where Flourens and Steinrueck upheld the theories started in this country.

The investigations of Waller, Vulpian, and Philippeaux, about the year 1852, brought a new light to bear on this subject, and formed the first step in the accurate pathology of nerve lesions. It was shown by these physiologists that the peripheral end of a divided nerve underwent degeneration, and that some months

intervened before the nervous substance was repaired. Theoretically, then, a corresponding time should always intervene before the nervous functions were re-established; and thus, though the theory of inevitable nerve regeneration was not relinquished, it was assumed that union never could take place by first intention. But the eyes of surgeons could no longer be shut to the cases which constantly came under their notice, and as experimental inquiry yielded to clinical observation, the fact was speedily established that in a large number of patients suffering from nerve lesions, no union of any kind occurred.

In this branch of pathology, however, as in many others, the discretion of pathologists speedily outran their wisdom, and the theory of "supplementary sensibility" and "supplementary motility" was, especially by French surgeons and physiologists, adopted, to the exclusion of nerve regeneration, and more especially to that of reunion by first intention.

In a former chapter I have discussed the probabilities and evidence in favour of union by this latter method, and also the evidence bearing upon the presence and amount of nerve anastomoses and supplementary sensation; I shall therefore take for granted that the possibility of immediate union is an established fact, and shall now pass on to consider the best means at our disposal for procuring it.

Suture of Nerves.—In order that any tissues which have been divided by the surgeon or else by accident should unite as speedily as possible, it is plainly of the first importance that they shall be closely approximated. How should this approximation be maintained in the case of divided nerves? To this question there can be, in my opinion, but one answer, "By suture;" and the reason that this answer has not been given very many years ago is to be found in the erroneous views as to the probable results—*e.g.*, tetanus, &c.—of the irritation which the stitches might set up, as well as in the mistaken ideas of nerve repair just alluded to.

Putting aside the more than doubtful assertion that nerve suture was performed in the Middle Ages by Lanfranc, Guy de Chauliac, &c., the operation is said to have been performed by Arnemann in 1826, and by Flourens in 1828. At a later date it was practised in several instances by Dupuytren at the Hôtel Dieu.

But, although these cases are interesting from an historical

point of view, the time when nerve suture came to be practised in surgery on a definite physiological basis is much more recent, and may be said to date from 1864 when Laugier, a French surgeon, sutured the ends of a recently divided median nerve. Laugier claimed that immediate union resulted, but whether this was or was not the case is not sufficiently clear.

In 1865, MM. Eulenberg and Landois made numerous experiments on animals, and concluded that not only does the peripheral end of the divided nerve degenerate in a manner precisely similar to that noticed when no sutures are used, but that the sutures themselves are absolutely harmful, producing neuritis and perineuritis, and may even give rise to suppuration and secondary abscesses in the lungs.

These statements, combined with the ever-present dread of tetanus, naturally dissuaded surgeons from universally adopting such measures; and, in 1868, Boeckel of Strasburg related a case in which, after division of the median at the wrist, there was a recurrence of sensation in two months, except in the index finger; no sutures had been used, and the author rather illogically concluded that they were never necessary.

Some years later Le Dentu noted that bullæ occurred on the fingers after an attempt had been made to procure immediate union by suture of a recently divided median; this lesion he attributed to the irritation caused by the sutures, and not to the cutting off of the nervous influence.

There can be but little doubt that this conclusion was an erroneous one, for, as I have already endeavoured to prove, these trophic lesions are not of an irritative nature, and the bullæ were no doubt due to a failure of union by first intention, and not to the presence of the catgut.

But the results obtained by Eulenberg and Landois are entirely different to those of other experimenters, some of whom in vain attempted to induce neuritis by means of setons and other irritants; and, what is of much more importance, amongst a large number of cases in which sutures were applied to human nerves these much dreaded consequences were conspicuous by their absence.

The result of further experience has thus come to be that, as far as any danger is concerned, no surgeon would hesitate to use the most obvious means of approximating the ends of a divided nerve, and would fearlessly insert as many stitches as might be necessary,

without any dread. But, putting the danger out of the question, is the patient any more likely to have the continuity of his nerve restored if the ends are sutured than if they are left to nature? To this I would answer most unhesitatingly in the affirmative, for judging by accounts published by various authors, and by my own observations, I can have no doubt but that in the vast majority of untreated nerve-wounds, either no union at all, or but a most imperfect one, can be expected. That the ends are sometimes united even if left to themselves, is proved by some of the cases already narrated, but under these circumstances a primary union can rarely occur, for the ends are but seldom in apposition, a state which is absolutely necessary for this method of healing. And again, in cases where primary union fails, by the time when degeneration and regeneration have occurred in the distal fragment, it very frequently happens that in the process of cicatrization the nerve-ends have either become adherent to the surrounding muscles and tendons, or else are widely separated by fibrous tissue which forms an impenetrable obstacle to further attempts at reunion.

These latter conditions at any rate can be obviated by the employment of sutures, and even if union by first intention fails, the nerve is left in a much more favourable condition for subsequent regeneration than is otherwise the case.

Now the experiments by Glück proved very clearly that in fowls, rabbits, &c., the use of sutures was followed by a rapid reunion of the divided nerve, and on these grounds an analogous result in man might fairly be expected. The records, however, of cases in which such treatment has been adopted affords information of a much more valuable nature, and it is to the evidence afforded by such cases that I would direct attention rather than pursue theoretical arguments any further.

Primary Nerve Suture.—The operations which may be undertaken for the suture of divided nerves are conveniently divided into two classes—primary and secondary.

The operation of “primary suture” consists in stitching together the ends of a divided nerve, either immediately after injury, or else very shortly afterwards—before, in fact, the process of healing of the wound has commenced.

This operation, in my opinion, should be performed in every case of nerve injury in which it is possible. There are, of course, cases in which such an extent of nerve has been removed

that it becomes a physical impossibility to bring the severed ends into apposition, and in such alone should the operation be omitted.

I have no doubt—and I shall hope to adduce the proof—that the operation of nerve suture is absolutely harmless; that when the nerve-ends are left unsutured union is most unlikely to occur at all, and at best is very imperfect; lastly, that when the nerve-ends are carefully sutured and maintained in apposition, a restoration of function is the most frequent result.

Under this belief, I cannot agree with those surgeons who consider that in cases of clean-cut wounds sutures should not be inserted. I believe these are just the cases best suited for suture. M. Nicaise, in his article on “Injuries of Nerves,” in the *International Encyclopædia of Surgery*, says, “when the section is clean-cut and simple, without extensive wound of the integument, the suture should not be resorted to, unless the separation is considerable;” and other surgeons, especially on the Continent, express the same opinion.

I am perfectly convinced that such advice should not be followed. No possible harm can result from suture, and the prognosis in the case of a wounded nerve left to itself is most unsatisfactory.

The Mode of Application of the Suture is a matter which has received much more attention than it really deserves. For a long time it was taught that the sutures should only be passed through the nerve-sheath, and that it was dangerous to pass the needle through the bundles of nerve-tubes themselves. This again was all due to theory, and surgeons have gradually learnt that the thought of danger is one with which they need not trouble themselves when considering the best method of fixing the separated nerve-ends in apposition.

I have myself passed sutures completely through human nerves, and have frequently seen them passed by others, without the slightest evil result; and in the now numerous cases recorded in surgical literature the same treatment has been followed without a single recorded instance of any complication.

The method which I would recommend is the following:—A small needle armed with the suture should be passed completely through the nerve-trunk, at right angles to its long axis, about a quarter of an inch from the cut surface in each end, and in large trunks another suture may be passed at right angles to the

first. These sutures should then be drawn tight until the opposing cut surfaces are brought into contact, and finally, if the trunk be a large one, the edges of the sheath should be neatly stitched by two or more sutures passed so as to include within it all the cut tubules.

The Material for Suture.—The choice of a material for suture is naturally influenced by the same considerations as those which obtain in the similar operation of ligature of vessels, and just as in the latter it is advisable to use a tissue which will not act as an irritant and will be absorbed, so is a similar material indicated in the suture of nerves.

In the majority of recorded cases catgut has been used, and I am inclined to consider that for small nerves carbolized catgut is the best material for suture.

In those cases, however, in which there is any unusual tension, or in which it is anticipated that on account of any complication it may be necessary to disturb the wound, I think that carbolized gut does not possess the necessary amount of resisting power, and does not last a sufficient length of time. In such cases I should use by preference a more stable ligature, such as chromicized catgut, kangaroo tendon split into sufficiently small filaments, horsehair, or fine silk; I prefer the two former to the latter.

After apposition has been obtained by suture, the limb should be fixed on the splint in such a position as to keep the injured nerve in a state of the least possible tension.

The wound should be thoroughly cleansed, all sutures used should be first rendered aseptic, and every endeavour should be made to ensure healing by first intention.

The following cases, however, I think obviate the necessity for further description, and apart from the question of suture they possess numerous points of interest, and illustrate much of what I have written in former chapters on trophic changes and symptoms of nerve injuries.

Almost all these patients were treated in St. Bartholomew's Hospital, where they were under the care of various surgeons, but the course of each case has been run under my own observation, and the symptoms recorded and the improvement described in the following notes have been watched for and recorded by myself.

CASE I.—*Primary Suture of Median Nerve, with Union by First Intention and Rapid Restoration of Function.*

Henry H., aged twenty-three, was admitted into St. Bartholomew's Hospital, under Mr. Holden, on Nov. 20, 1881. He had fallen, with outstretched hands, on to some sheets of loose glass, a few minutes before arriving at the hospital. On examination there was found a large lacerated wound about one inch above the palmar surface of the right wrist, a flap of skin and muscle being turned downwards towards the palm of the hand. The whole of the flexor tendons of the wrist and fingers were divided except the flexor carpi ulnaris and the innermost tendon of the flexor sublimis digitorum. A small piece of bone was cut out of the radius and the pronator quadratus was torn. The radial and interosseous arteries bled freely, and were tied. The arteria comes nervi mediani, which was large, was similarly treated. The median nerve had been divided in two places and the intervening portion of it, nearly one inch in length, lay loose in the wound, and was accordingly removed. I then drew down the upper end as forcibly as possible, and sutured it to the lower portion with carbolized catgut. As many tendons as possible were similarly fixed, and the wound dressed with carbolized oil, the hand being steadied in a position of flexion by means of a splint.

Nov. 21st.—Much pain in the hand. No sensation in the parts supplied by the median nerve.

22nd.—The edges of the skin have sloughed, but the deeper parts look healthy.

Dec. 1st.—Sensation has been tested daily, but this morning for the first time he can tell which finger is pricked with a pin. No pain. A good deal of the wound has healed, and the rest is granulating.

3rd.—With his eyes blindfold he can now tell with certainty which finger is touched with the handle of a pen. The prick of a pin causes pain.

7th.—Sensation in the thumb, index and middle fingers is nearly perfect. He can feel the slightest touch, and can localize it accurately. He is fully sensitive to the pain of a prick and can move the fingers slightly.

16th.—The hand is much improved in the power of flexion. He can thoroughly oppose the thumb, and can pick up a pin easily.

He says he has still a slight sensation of numbness. The fingers are all quite warm and fully sensitive to all stimuli.

24th.—The wound has healed except for a very slight ulceration opposite the seat of injury to the radius. He says that, but for some stiffness in the fingers, the hand feels much the same as the other. He has increased power of movement in the fingers and thumb.

Eight months later this patient came to show himself at the hospital. He could not quite bend the fingers into the palm owing to an adhesion of the tendons to the scar, otherwise there was no difference between the two hands, and the man said that he could work and feel as well with one as with the other.

CASE II.—*Primary Suture of Median Nerve.—Primary Union.—Success.*

The patient, a lad aged thirteen, cut his right wrist on Nov. 29, 1884. Mr. Menzies sutured the ends of the median nerve with catgut. It had been completely divided.

Dec. 1st.—There was considerable return of sensation.

6th.—Sensation was normal, except at tip of index.

20th.—Sensation normal.

Jan. 20, 1885.—The patient uses the hand as well as before the injury.

July 20th.—One hand quite as good as the other. No wasting or paralysis. (This case is detailed more fully at p. 34.)

The two preceding cases have already been detailed in connection with the question of "primary union," of the possibility of which they each afford ample evidence.

In each patient the effect of suture was to promote union with such rapidity that the nerve-ends were completely united before the skin wound was healed. Had no sutures been used, I feel quite certain that union would not have occurred at all in the first case, in which an inch of nerve had been cut out, whilst I am further of opinion that it is most unlikely to have occurred in Case II.

CASE III.—*Primary Suture of the Median Nerve.—Success.*

Robert C., aged seventeen, was admitted into St. Bartholomew's Hospital, under Mr. Smith, on May 17, 1882. He had put his

hand through a pane of glass, and sustained a lacerated wound of the front of the wrist. The wrist-joint was opened, the radial artery and the median nerve were divided, as were also the tendons of the flexor carpi radialis. The nerve and tendons were sutured with catgut and the wrist kept flexed. The operation of suture was followed by some return of sensation in the thumb, index and middle fingers. I did not see this patient until October 31st, when I found his condition as follows: Wrist ankylosed; no pain. Muscles of the ball of the thumb wasted slightly. Scarcely any power of opposition; thumb rotated out. The joints of the index and middle fingers are stiff. Sensation: Nowhere complete anæsthesia, but sensation is much impaired over the palmar surface of the index and middle fingers and of the thumb. The dorsal surface of the second and third phalanges of the index and middle fingers are partially anæsthetic. He has slight sense of pain in the area of diminished sensation. No sense of temperature in the same region. No trophic changes except in the nails, and these are all curved, ridged, and furrowed, fibrous and brittle. Nails of the ring and little fingers are in a similar condition to those of the index, middle, and thumb. The nail of the latter has been shed, and the present nail is not fully grown.

April 17, 1883.—Hand much more plump; good movement of the thumb. The opponens and abductor pollicis act well. Sensation: Can localize everywhere. There is now but very little impairment. The nails are all quite natural, except that of the index finger, which is a little furrowed.

This patient was unfortunately lost sight of before his case was complete, but when last seen he had improved so rapidly that I have always considered the case a successful one. At any rate, the hand was useful and strong, and but little evidence of impairment in the nerve-supply remained.

The case is further interesting, as showing that after section of the median nerve trophic changes are liable to occur in the nails of the ring and little fingers. I have appended drawings to show the condition of the nails at different dates.

CASE IV.—*Primary Suture of Median Nerve at the Elbow.—Success.*

Philip D., aged fourteen, was admitted into St. Bartholomew's Hospital, under Mr. Smith, on Sept. 6, 1877. He had sus-

tained a lacerated wound two inches above the elbow, dividing the median nerve and fracturing the internal condyle. The nerve was sutured by catgut. The wound healed slowly, but sensation rapidly returned in the fingers, and by October 28 he could feel a touch in any part of the median distribution.

July, 1882.—Hand is perfectly normal in every respect. There is no impairment of either motion or sensation.

CASE V.—*Primary Suture of Median Nerve.—Success.*

John G., aged twelve, was admitted into St. Bartholomew's Hospital on Nov. 2, 1881, suffering from a deep wound of the wrist, which had divided the median and ulnar nerves, almost all the tendons, and had opened the wrist-joint. The nerves were sutured with catgut, and the wound suppurated extensively. The patient recovered with an ankylosed wrist-joint.

Aug. 19, 1882.—His condition is as follows: A deep scar about one inch and a half above the wrist, adherent to the ulna, but not painful. All the fingers partially flexed, especially the little finger. Slight movement of the thumb, which is not contracted. The muscles supplied by the ulnar nerve are all very much wasted, those supplied by the median somewhat less so. The hand is clawed. The patient says that the hand sweats very much in hot weather. The skin over the front of the palm is smooth and glazed, as well as on the palmar surface of parts of the fingers. The back of the hand is natural, as is also the dorsal surface of the thumb, index and middle fingers; the ring and little fingers are shiny. There is almost complete absence of hair on the fingers. The nails are stumpy and broken, arched, and ridged in a very peculiar manner at their bases. The little finger nail came off eight months ago, and is now scarcely reformed. Sensation: He localizes fairly well on the palmar surface of the thumb, index and middle fingers. The ring and little fingers are practically anæsthetic. The wrist is ankylosed and the hand useless.

April 20, 1883.—Hand much improved; ball of the thumb is thicker. He can oppose the thumb fairly well, and can partially flex the fingers. All the joints are more or less stiff, but they partially yield to extension, and the index finger is straighter than formerly. This stiffness of the joints is not due to contraction of the tendons. Sensation: Normal all over the hand and fingers.

FIG. 19.

Part of a hand after section of the median and ulnar nerves,
showing ridged, fibrous, and broken nails.



Fig. 19.

Sense of touch, temperature, and pain all natural. The nails are only slightly striated. He has no pain.

June 30th.—Has more power of flexion of the fingers and thumb. He says the hand is more useful and the fingers are less flexed.

Aug. 11th.—Except that the fingers are still flexed, the hand is in a natural condition.

March 25, 1884.—The fingers can be more extended; the joints are now no longer stiff, and the flexion appears to be maintained by the scar tissue, which binds the tendons at the seat of injury. There are no trophic changes. The muscles of the ball of the thumb and of the rest of the hand act well voluntarily, but there is no faradic contractility. He now has no pain in the hand, and it never feels numb.

In this case, as in Case III., the nails of the little and ring fingers were affected with trophic changes quite as much as those of the other digits, the nail of the little finger being shed. The length of time that ensued before any repair occurred is worthy of notice, and is a fact to which I shall again allude. The wasting and regeneration of the muscles, the stiffening and relaxation of the joints, are also points of much interest.

CASE VI.—*Primary Suture of Median Nerve at the Wrist.—Success.*

George H., aged thirteen, was admitted into St. Bartholomew's Hospital, under Mr. Smith, on May 20, 1879. He had thrust his hand through a window and sustained a wound one inch and a half above the wrist, which divided the median nerve, the palmaris longus tendon, and two tendons of the flexor sublimis digitorum, as well as the radial artery. The divided nerve was sutured by catgut.

22nd.—The wound is suppurating.

30th.—Sensation has returned, except in the index finger.

July 2nd.—The wound has healed. He can feel in all fingers. Discharged.

July 11, 1882.—The one hand is quite as good as the other. Sensation and motion are perfect, except that the tip of the index finger is a little numb. The scar is sound, not painful, but slightly tender. All the muscles supplied by the damaged nerve act normally.

CASE VII.—*Primary Suture of Median Nerve.—Rapid Return of Sensation.—Cure.*

Harry J., aged fifteen, a warehouseman, was admitted into St. Bartholomew's Hospital, under Mr. Baker, on Dec. 24, 1884. He had fallen on broken glass and cut his wrist. The median nerve and the palmaris longus were divided. The nerve was sutured with catgut at the time of the accident. There was complete anæsthesia of the palmar surface of the thumb, index and middle fingers, and of the dorsal surface of the last two phalanges of the index and middle.

Dec. 27th.—Sensation: Thumb: Localizes everywhere. Index finger: Third phalanx anæsthetic; second phalanx, slight sense of touch, but cannot localize; first phalanx localizes well. Middle finger same as index. The temperature between the index and middle is 96° ; between the ring and the little, 94° .

28th.—Wound healing well. Temperature between index and middle, $98^{\circ}.8$. Ring and little, 96° .

29th.—Electrical examination: Faradic contractility lost in the median muscles. Reaction of degeneration is marked in the same muscles, the anodic closure contraction being greater than the kathodic closure contraction. The temperature in the paralysed parts has fallen, being only $97^{\circ}.6$ between index and middle, and $98^{\circ}.4$ between the ring and little.

Jan. 19, 1885.—Discharged. No further change.

March 10th.—Very slight further improvement. He is galvanized regularly.

July 9th.—Is practically well. Sensation: Localizes everywhere. Sense of pain and of temperature normal. The hand is in capital condition, strong and useful. He has good power in all the muscles of the thumb. Electrical examination: No electrical excitability. Trophic: All the nails are coming off, *those of the ring and little fingers* the same as those of the other fingers. The new nails are three-parts grown. The hand is quite warm.

Sept. 17th.—Except for slight numbness in the median distribution, the hand is perfectly well. The nails are all normal, and the muscles supplied by the median nerve react to faradism.

It is extremely difficult to say whether the amount of sensation which was present within a few days of suture, is to be attributed to a reunion of the divided fibres, or to sensations conveyed by

nerves other than the one injured. I am inclined to think that there was primary union of some of the fibres, chiefly for the reason that it was noted before suture that "there was complete anæsthesia of the palmar surface of the thumb, index and middle fingers, and of the dorsal surface of the last two phalanges of the index and middle fingers." I find another reason for this belief in the rapid improvement of the sensation noted as present the day after the injury, and in the rapidity with which the whole nerve was subsequently united.

The return of voluntary power before electrical excitability, and the affection of the nails of the ring and little fingers, are also points worthy of attention.

CASE VIII.—*Partial Division of the Median Nerve.—Primary Suture.—Success.*

R. W., aged forty-four, was admitted into St. Bartholomew's Hospital, under Mr. Willett, July 6, 1882, having sustained a cut above the elbow, dividing the biceps and part of the median nerve. Catgut sutures were passed through the nerve, the ends of which were partly separated.

11th.—The wound is suppurating. Sensation—Thumb: Tactile sensation impaired over the distal phalanx, but good over the proximal. Sense of pain and temperature also impaired. Index: No tactile sensation. No sense of pain or temperature on the palmar surface or upon the dorsal surface of the last two phalanges. Middle finger: No tactile sensation. There is pain on deep pressure by a pin at the tip, but not elsewhere. No sense of temperature. The palm and back of the hand, and the fourth and fifth fingers are normal. There appears to be partial paralysis of the abductor and opponens pollicis.

15th.—Erysipelas extending from the wound.

26th.—Erysipelas has faded. No material alteration in sensation.

Aug. 19th.—Sensation much improved. He can distinguish two points separated a quarter of an inch at the back of the index and middle fingers, and can localize everywhere the touch of a pencil.

Oct. 27th.—The forearm is wasted, the muscles feel firm and hard. Supination is limited. The muscles of the ball of the thumb are much wasted, and there is no power of opposition.

There are no nutritive lesions. Sensation in the thumb is good.

April 17, 1883.—Sensation very slightly impaired anywhere. Not so much muscular wasting, and some return of power in the opponens pollicis. He says that since the last note his nails have become misshapen; that at first they were very tender, but this has passed off. Now they are ridged at the tips with a single ridge as if a part of the old nail were to be separated from the new one. *All the nails are affected, including those of the ring and little fingers.*

May 22nd.—He continues to improve. Sensation is more acute. He can pick up any small object between the thumb and any of the fingers. He has returned to his work, and finds his hand quite useful for anything that he is called upon to do. He gets as good wages as formerly. The nails are not much altered.

Aug. 9th.—Sensation is good over all the median distribution, quite perfect in the thumb, and scarcely at all impaired in the index and middle fingers. There is much improved power in the muscles supplied by the median nerve. The nails are normal.

Dec. 3rd.—Still some wasting of the radial side of the hand.

March 26, 1884.—Sensation is quite perfect. The muscles are much restored in bulk. The one forearm measures as much as the other. The opponens and other median muscles can all be used. Electrical examination: All the muscles supplied by the median nerve react to faradism for the first time since the injury.

April 8th.—All the muscles act to faradism, both through the nerve-trunk and also directly. The patient is now completely well.

In this patient one year and eight months elapsed from the time of injury before the electrical excitability of the paralysed muscles returned. The progress of this case was throughout slow.

CASE IX.—*Primary Suture of Median Nerve.—Partial Success.*

John C., aged seventeen, put his hand through a window-pane on July 31, 1887, and divided his median nerve and some tendons,

all of which were sutured with catgut. The wound healed in three weeks, after a little suppuration.

Sept. 28, 1888.—Localizes everywhere, but sensation is still much impaired. The middle and index fingers are blue and cold. The thumb is normal, and the muscles of the ball of the thumb are in good condition, and act voluntarily.

CASE X.—*Primary Suture of Median Nerve.—Partial Success.*

Mary T., aged fifty, was admitted into St. Bartholomew's Hospital, under Mr. Willett, on Aug. 22, 1886. She had put her hand through a glass door, and divided her median nerve and some of the tendons two inches above the wrist-joint. The tendons and the nerve were sutured with kangaroo tendon ligatures, and the wound healed by first intention.

Sept. 23rd.—No return of sensation or motion.

Feb. 4, 1887.—Localizes the least touch everywhere. Slight return of voluntary power; slight reaction to galvanism and K.C.C. > A.C.C. No reaction to faradism. Joints of fingers stiff, and skin shiny. The nail of the ring finger has come off.

Sept. 28, 1888.—Hand useful and painless. Good sensation, but muscles supplied by median still feeble and wasted.

CASE XI.—*Primary Suture of Median Nerve.—Partial Success.*

Annie B., aged twenty-seven, was admitted into St. Bartholomew's Hospital, under Mr. Langton, on Sept. 27, 1885, having, whilst drunk, thrust her hand through a window-pane, and divided her median nerve just above the wrist, together with some of the flexor tendons. The nerve was sutured with four stitches of carbolized catgut, and the hand fixed on a splint. Eleven hours after the accident I found that she had lost sensation over the ball of the thumb and the palmar surfaces of the thumb, index, and half the middle finger, the other half of the middle digit and the ring finger being normal. The back of the thumb was normal, but the skin over the back of the last two phalanges of the index and half the same area in the middle finger was numbed.

28th.—The temperature between the index and middle fingers was 99°, and between the ring and little fingers, 96°.6.

29th.—There was a slight return of sensation in the ball of the thumb and the index finger.

Oct. 5th.—Wound quite healed. Sensation over index further improved.

9th.—Return of tactile sensation in front of thumb and index.

20th.—Electrical examination.—Faradism: No reaction of muscles supplied by the median nerve. Galvanism: Marked loss of galvanic irritability and A.C.C. > K.C.C. in the muscles of the ball of the thumb.

30th.—The muscles supplied by the median nerve require eighteen more cells to make them react than do those of the other hand, A.C.C. > K.C.C.

Nov. 2nd.—Localizes everywhere except over the last two phalanges of the index finger. After this the patient was lost sight of.

CASE XII.—*Primary Suture of Median Nerve.—Sloughing of Wound.—Failure.*

Frank Y., aged forty, was admitted into St. Bartholomew's Hospital, under Mr. Baker, on Sept. 10, 1886, having cut his wrist eighteen hours previously by thrusting his hand through a window-pane. His median nerve and some tendons were found to have been divided, and were accordingly sutured with kangaroo tendon ligatures. The wound suppurated freely, and subsequently the exposed nerve and tendons sloughed, so that on his discharge, two months later, the patient had no return of sensation or of motion.

CASE XIII.—*Primary Suture of Ulnar Nerve, with Return of Function, after several years.*

Edward W., aged thirty-three, fell through a skylight and divided the ulnar nerve and the superficial flexors in the middle of the forearm. He was admitted into St. Bartholomew's Hospital, under Mr. Savory, on June 14, 1881. The nerve was sutured with catgut. The fourth finger and half the fifth were anæsthetic, as was also the ulnar half of the hand.

June 17th.—Slight return of sensation.

July 28th.—Further return of sensation in the ring finger, but none at all in the fifth.

July 17, 1882.—The patient has a large depressed scar on the inner side of the upper forearm, not painful or tender. The forearm is wasted, especially on the inner side. The ball of the little

finger is flattened, and the adductor and flexor brevis pollicis are wasted. The interossei muscles also are wasted, and all these muscles are paralysed. The nutrition of the skin is good. The patient has had no blisters and no sore places. The nails are normal, and the ring and little fingers are colder than the others. The patient says that the inner side of his hand and the fourth and fifth fingers never sweat. Sensation: Impaired slightly on the lower part of the forearm on the ulnar side. Fifth finger: He can feel the touch of a pencil, but cannot localize it over the palmar surface of the first phalanx. There is slight thermic sense, but no sense of pain in the ring finger, and slight impairment of sensation on its inner side. He can localize everywhere on this finger, and has sense of temperature and of pain. On the ulnar side of the palm there is partial loss of sensation.

April 23, 1883.—The hand is very greatly improved. The muscles are almost, if not quite, as large as those on the other side. There is no perceptible wasting, and no nutritive lesions. Sensation: Normal in forearm, ring finger, and palm of hand. On the little finger he does not localize quite accurately, except at the tip.

Aug. 13th.—He localizes well everywhere, but there is slight loss of acuteness.

March 27, 1884.—Sensation further improved. It is now scarcely at all impaired. The muscles of the ball of the little finger react to faradism, as do also the interossei. The fingers are nearly straight. The hand is useful and strong, and scarcely at all numb.

March 25, 1885.—He is practically well, except that he cannot spread the fingers in a natural manner.

Sept. 21st.—Quite well. Sensation, and motion of all muscles alike perfect. The electrical reactions of all the muscles of the hand to faradism and to galvanism are normal.

CASE XIV.—*Primary Suture of Ulnar Nerve.—Success.*

Alice D., aged twenty-four, was admitted to St. Bartholomew's Hospital, under Mr. Savory, on June 17, 1879. She had thrust her arm through a window-pane, and divided the ulnar nerve behind the elbow. The nerve was sutured with catgut. There was complete loss of sensation in the little finger and ulnar side of the hand, with partial anæsthesia of the ulnar side of the ring finger.

Sept. 6th.—As there had been no improvement in sensation, the nerve was exposed behind the elbow, and was found to be apparently completely united.

July 14, 1882.—The patient wrote to say: "I am most happy to inform you that I have quite recovered the use of my arm. I find no difficulty in bending or using it, and no pain whatever. The little finger swells in cold weather, but at other times I feel no difference."

The chief point of interest in this case is that, although the continuity of the nerve appeared to the naked eye to be restored, nevertheless the functions were entirely in abeyance.

CASE XV.—*Division of Ulnar Nerve.—Primary Suture.—Success.*

J. D., aged thirteen, was admitted, under Mr. Savory, to St. Bartholomew's Hospital on Aug. 12, 1885, with a cut on the right wrist caused by falling on to some broken glass. The flexor carpi ulnaris and the ulnar nerve were divided. The nerve and tendon were sutured with catgut. The early notes as to loss of sensation are of doubtful value. I did not see the case until the 17th of September.

Sept. 17th.—Sensation—Little finger: Anæsthetic. Ring finger: Can localize everywhere. The skin over the fourth and fifth metacarpals, back and front, has much impaired sensation. There is complete anæsthesia on the ulnar edge of the hand. Trophic changes: None. Muscles: Hand clawed. All ulnar muscles paralysed.

Oct. 2nd.—Discharged. There is now very evident wasting of the interossei and the hypothenar eminence. The wound is even now barely healed.

Feb. 4, 1886.—Sensation greatly improved. Localizes everywhere. No trophic lesions. Muscles wasted and paralysed.

Oct. 1888.—The hand is practically quite well. The muscles are not at all wasted, and the grasp of the hand is strong. The interossei, however, are feeble, and do not separate the fingers completely. The little finger is a good deal abducted. Sensation is good, and the patient says he only feels a little numbness in cold weather. He localizes quickly and accurately everywhere.

CASE XVI.—*Primary Suture of Ulnar Nerve.—Success.*

Minnie D., aged twenty-five, thrust her hand through a window-pane on Feb. 6, 1887, and divided her ulnar nerve and artery, and some tendons. On admission into St. Bartholomew's Hospital, under Mr. Langton, she was found to have lost sensation in all the parts supplied by the ulnar nerve, the cut ends of which were accordingly sutured with catgut. The wound healed with but little suppuration, and by Feb. 31st sensation had returned in the ring and little fingers, though the power of correct localization was wanting. The patient then left the hospital, and I did not see her again until October 1888, when I found her hand completely recovered, sensation and motion being perfect, except for slight feebleness of the interossei. The muscles reacted to both faradism and galvanism, but A.C.C. > K.C.C.

CASE XVII.—*Wound of Ulnar Nerve and Artery.
Primary Suture.—Success.*

E. A., a lad, aged seventeen, was admitted on Aug. 10, 1886, under Mr. Morratt Baker, with a history that he had fallen and cut his wrist with a broken glass. He was found to have divided his ulnar nerve and artery on the right side one inch above the wrist. The nerve was sutured with catgut. The wound suppurated, and did not heal till the 28th. Sensation was lost in the typical ulnar area, and there was typical ulnar paralysis.

Feb. 9, 1887.—Can feel a little when touched, but cannot localize. A touch causes sensation of "pins and needles." Muscles wasted, but not excessively so. The little finger is abducted. There is no clawing. Electrical examination: No reaction to faradism. Reacts to galvanism, thirty-two cells, but A.C.C. > K.C.C. Query: Is this a *degenerative* reaction modified by nerve suture, or a returning reaction due to *regeneration*? It is difficult to say.

Nov. 22, 1888.—The hand is practically well. He can localize the slightest touch everywhere, but says that the feeling is not yet the same as in the unaffected fingers. The shape of the hand is normal, and all the muscles supplied by the ulnar nerve are well developed and act vigorously. The grasp of the hand is strong. The interossei act well, but the fingers cannot be separated quite so well as can those of the other hand. There is also

slight abduction of the little finger. The patient says the hand is quite as useful as before the accident. Electrical examination shows normal reaction to faradism, but to galvanism A.C.C. > K.C.C. There are no trophic lesions, and the joints are natural.

CASE XVIII.—*Primary Suture of the Ulnar Nerve.—Increased Temperature in the Paralysed Parts.—Great Improvement after three years.*

George H., aged thirty, was admitted into St. Bartholomew's Hospital, under Mr. Langton, on March 8, 1885. He had thrust his arm through a pane of glass, and received a cut over the internal condyle of the humerus. The ulnar nerve was completely divided, and was sutured with three catgut and two horsehair sutures.

May 9th.—Eight hours after the accident the temperature between the fourth and fifth fingers was $100^{\circ}.2$; between the first and second, 99° . At 7.30 P.M., in the same situation, between the fourth and fifth, 99° ; first and second, 98° .

10th.—Between the fourth and fifth, $99^{\circ}.6$; between first and second, $98^{\circ}.2$.

11th.—Between the fourth and fifth, $98^{\circ}.6$; between first and second, $97^{\circ}.6$.

14th.—Between the fourth and fifth, 98° ; between first and second, $97^{\circ}.4$.

15th.—Between the fourth and fifth, $98^{\circ}.2$; between first and second, $98^{\circ}.2$.

16th.—Between the fourth and fifth, $101^{\circ}.6$; between first and second, $101^{\circ}.6$.

19th.—Between the fourth and fifth, $99^{\circ}.4$; between first and second, $98^{\circ}.8$.

20th.—Between the fourth and fifth, 98° ; between first and second, $97^{\circ}.6$.

21st.—Between the fourth and fifth, 99° ; between first and second, 98° .

The temperature of the paralysed parts remained generally about one degree higher than that of the rest of the hand until his discharge on May 30th, and varied with his body temperature.

May 11th.—Electrical examination: The interossei react to faradism, and to galvanism, there is no loss of excitability. The anodic closure contraction equals the kathodic closure contraction.

13th.—Electrical examination: Complete loss of faradic contractility of the ulnar muscles, and no appreciable reaction to galvanism.

14th.—Sensation: Little finger quite anæsthetic. Ring finger: Can localize occasionally on the ulnar side. The wound is suppurating.

30th.—There has been much suppuration, and sensation has not improved. The muscles supplied by the ulnar nerve are all paralysed.

June 18th.—Has improved. He can localize all over the inner side of the little finger, and palm and back of the hand. There is complete anæsthesia of the outer side of the little finger and along the fourth interosseous space on the back. There is much œdema of the hand. No pain or trophic lesions.

Sept. 19th.—No further alteration. No reaction to galvanism or faradism.

July 13, 1886.—Tactile sensation much improved, but still does not localize accurately. Muscles still paralysed.

Feb. 4, 1887.—Localizes badly, but feels a touch readily. Slight voluntary power over hypotenar muscles, none over interossei. The former act feebly to both faradism and galvanism (K.C.C. > A.C.C.), the latter do not act.

Oct. 31, 1888.—There is no wasting of the forearm, and the flexor carpi ulnaris and the muscles of the ball of the little finger have good voluntary power. The interossei are still wasted and paralysed. Sensation is much improved and he can quickly and readily feel and localize the slightest touch. He says, nevertheless, that sensation is not quite natural and that he has feelings of “pins and needles.” The hand is useful and strong, and he says has much improved during the summer.

In each of the last two cases the electrical reactions after nerve section are well demonstrated, and support the views I have already advanced of the much more rapid loss of excitability in man than in animals, and the absence of that increased galvanic irritability noted after nerve lesions in the latter.

CASE XIX.—*Primary Suture of Ulnar Nerve—Improvement.*

James D., aged thirty-two, was admitted into St. Bartholomew's Hospital, under Mr. Baker, on April 7, 1885. He had thrust his hand through a window and had met with an incised wound on the

ulnar side of the right wrist. The ulnar artery and nerve and flexor carpi ulnaris tendon were divided, also the two inner tendons of the flexor sublimis digitorum. The nerve was sutured by two silk ligatures passing through the sheath.

9th.—Sensation was found to be lost in all the ulnar distribution. The wound was healing well. Electrical examination: No response to interrupted current in the ulnar muscles. Good reaction to galvanism.

14th.—No definite reaction to either the continuous or the interrupted current. When discharged from the hospital a week later, there was no return of sensation in the little finger or the ulnar side of the palm or back of the hand, or on the ulnar side of the ring finger. There was no return of power in the muscles of the hypothenar eminence.

July 10th.—All the ulnar muscles are much wasted and completely paralysed. The little finger is clawed and the phalangeal joints stiffened. No reaction to electricity. No trophic changes. Sensation: Localizes on the inner side of the little finger and on the palm, and feels a touch, but cannot localize it, on all other parts of the hand supplied by the ulnar nerve. He says the little finger and part of the ring feel very numb.

This patient died seven months later from acute rheumatism, but I was not able to examine his nerve, as I did not hear of his death at the time.

CASE XX.—*Primary Suture of Ulnar Nerve.—Partial Success.*

Sarah S., aged fifty, was admitted into Lucas Ward, St. Bartholomew's Hospital, under Mr. Langton, on Jan. 11, 1886, having divided her ulnar nerve just above the wrist by falling on a broken jug. She had lost sensation in the parts supplied by the ulnar nerve and had divided the ulnar artery also. The nerve was sutured with catgut, but the wound suppurated freely and did not heal for more than a month, when the patient left the hospital.

July 16th.—No return of sensation; muscles not much wasted. All the nails are ridged, furrowed, and brittle.

Feb. 4, 1887.—Some return of sensation and of power of localization on the palmar surfaces of the ring and little fingers. Muscles still wasted, but some return of voluntary power and very little deformity. There is slight reaction to galvanism and A.C.C. > K.C.C.

Oct. 1888.—No further change.

CASE XXI.—*Primary Suture of Ulnar Nerve—Partial Success.*

Henry T., aged sixteen, put his hand through a window on June 7, 1887, and divided his ulnar nerve just above the wrist. The cut ends were sutured with three catgut sutures, and the wound healed after a little suppuration in seventeen days.

On June 29th the galvanic irritability was very much impaired, but K.C.C. > A.C.C. No reaction to faradism.

Oct. 1888.—Localizes well and accurately, but sensation is still numbed. He says that when cold the hand is painful, but otherwise painless and useful. The muscles supplied by the ulnar nerve are still wasted and paralysed.

CASE XXII.—*Primary Suture of Ulnar Nerve at the Elbow. Sloughing of the Wound—Failure.*

Emile M., aged forty-seven, was admitted into St. Bartholomew's Hospital, under Mr. Willett, on Feb. 22, 1884. On the day of admission the patient fell on to some bottles in a cellar and cut his arm severely with the broken glass. On admission he was found to have sustained an extensive wound behind the internal condyle of the left elbow. The ends of the divided ulnar nerve were found after some trouble, and sutured with Chinese silk.

23rd.—Sensation: Abolished over the little and half the ring finger and over the ulnar half of the wrist and hand. The wound was dressed with oiled lint, but the edges did not look like healing. The temperature between the fourth and fifth fingers was one-third of a degree higher than that of the rest of the hand.

25th.—Electrical examination: The hypothenar muscles no longer react to faradism, but the interossei react to a strong current.

Feb. 27th.—All reaction to faradism absent; slight return of tactile sensation on the back of the second phalanx of the little finger.

March 18th.—The wound has been sloughing extensively, but is now healed, or nearly so. Patient discharged without having undergone any further improvement.

April 28th.—Wound healed. The muscles supplied by the ulnar nerve are much wasted. The skin over the ulnar side of the palm is rough and dry. Sensation has returned in the ulnar

side of the tip of the ring finger and over the dorsal and palmar surfaces of the hand to such an extent that he can readily localize the touch of a pencil. The little finger is numb; there is no faradic reaction of the paralysed muscles, and no voluntary power.

Oct. 22nd.—Ulnar muscles of forearm and hand much wasted; no power over any of the ulnar muscles. The hand is much clawed, especially the little and ring fingers. Sensation: ring finger good all over; little finger: he localizes over a small area at the outer side of the second phalanx behind, not elsewhere; hand: back fairly good, side and front much impaired.

March 25, 1885.—The hand is altogether more strong and useful; in fact, he says it gives him little inconvenience; there is, however, no further evidence of nerve regeneration. Pressure on the ulnar nerve in the forearm below the scar causes shooting pain in the parts supplied by the ulnar nerve.

July 12th.—No further change. He says the hand is quite useful and causes little inconvenience. The ulnar muscles continue paralysed and wasted.

CASE XXIII.—*Primary Suture of Ulnar Nerve.—Failure.*

William K., aged fifty-three, stableman, was admitted into St. Bartholomew's Hospital, under Mr. Holden, on July 12, 1879. He had fallen on a broken bottle and wounded his forearm in the middle third, dividing the flexor carpi ulnaris, two tendons of the flexor sublimis digitorum, and the ulnar artery and nerve. The nerve was sutured with catgut.

22nd.—There was slight return of sensation, but on his discharge on August 7th there was no sign of repair.

July 17, 1882.—Present condition: An adherent but not painful scar above the wrist. Marked wasting of the ball of the little finger and also of the inner part of the ball of the thumb. Interossei greatly wasted. Hand clawed. Nails are normal. Hair short and stumpy over first phalanx of the fifth finger. Patient says his hand never sweats, and has blisters on it in winter, but not in summer. The skin is smooth and shiny. He suffers no pain. Sensation: The fifth finger is absolutely anæsthetic, and the fourth finger is but little better. The inner side of the palm of the hand is quite anæsthetic, especially over a large scar, which, he says, marks the site of a previous

frostbite. There is no evidence of any union of the ulnar nerve.

CASE XXIV.—*Primary Suture of Ulnar Nerve.—Failure.*

Wm. R., aged thirty-one, was admitted into St. Bartholomew's Hospital on July 6, 1880. He had fallen through a window and cut nearly all the muscles of the inner side of the forearm, as well as the ulnar artery and nerve. The nerve was sutured with catgut.

7th.—Slight sensation down the ulnar side of the hand.

Aug. 6th.—Sensation has further returned.

July 18, 1882.—Present condition: Scar on forearm five inches above the wrist; not tender. No trophic disturbances of any kind. Fingers supplied by the ulnar nerve feel slightly colder than the others, and they are painful in cold weather. The muscles of the hand are much atrophied, especially the interossei. The fourth and fifth fingers are both flexed. Sensation: Palmar surface of fifth finger anæsthetic to all stimuli. He can feel on the back of the first phalanx, but refers sensation to the front of the hand. On the ulnar side of the ring finger he has sense of touch, but cannot localize. Sensation is impaired in the ulnar part of the palm of the hand. The muscles supplied by the ulnar nerve are paralysed.

April 23, 1883.—The hand is much more plump. The grip is firm. No trophic lesions. He says he has a numbing pain along the little finger and on the inner side of the hand, worse in cold weather and before rain. Sensation in ring finger normal; little finger anæsthetic.

Aug. 14th.—Hand still clawed, and muscles wasted and paralysed. No further improvement.

March 28, 1884.—No power over ulnar muscles; no reaction to faradism. No sign of reunion of the nerve.

CASE XXV.—*Primary Suture of Ulnar Nerve.—Failure.*
Secondary Suture seven weeks later.—Success.

Samuel B., aged seventeen, was admitted into St. Bartholomew's Hospital, May 11, 1881. He had inflicted a severe wound on the left side of the wrist with a chisel, and was bleeding profusely. On examining the injured arm I found that the ulnar artery and nerve were divided, as well as the flexor carpi ulnaris tendon. I accordingly ligatured the bleeding vessels and

sutured the divided ends both of the nerve and tendon with catgut. The arm was then fixed on a splint with the hand in a position of flexion. During the first few days there appeared to be a slight return of sensation in the parts supplied by the ulnar nerve, but after about ten days this disappeared, and up to the end of June there was no improvement. The muscles wasted, the grip of the hand became much weaker, and all the fingers were slightly extended at their metacarpophalangeal joints, whilst the distal phalanges were bent, especially those of the fifth finger, and to a less extent of the fourth. On July 1st the ulnar nerve was exposed by Mr. Langton by an incision about three inches in length; the divided ends were found separated by a space of about half an inch, but lying in the same plane and in the same straight line, and intimately united by a strip of connective tissue stretching between them. The upper end was slightly bulbous, and small portions of this as well as of the peripheral extremity were removed, the ends being subsequently sutured with both catgut and horsehair.

By July 7th there was a considerable return of sensation in the palm of the hand and the ulnar side of the ring finger. Improvement was slow, but on Dec. 3rd sensation was found to have returned everywhere, except over the last two phalanges of the little finger. At this time the interossei had increased in size, and the power of the hand was improved.

On Dec. 15, 1882, this patient wrote to say that his hand caused him no pain except in cold weather, that it was almost as strong as the other, and that his grasp was nearly as good. The fingers also were straighter, and continued to improve in this respect. In referring to sensation, he said he could feel a very slight touch or prick.

Oct. 20, 1885.—The patient came to see me. His hand is as good as before the accident. Electrical reactions are normal. The bulk of the muscles is the same as on the other hand; there is no stiffness of the joints.

This case has always seemed to me to be one of much practical importance. I attribute the failure of the primary suture to my own carelessness in not fixing the hand on a splint when the nerve-ends were only sutured with catgut. I can have no doubt that the latter yielded too soon, and allowed some incautious movement of the hand to separate the recently united ends.

CASE XXVI.—*Primary Suture of Ulnar and Median Nerves.*
Success.

Wm. P., engineer, was admitted into St. Bartholomew's Hospital, under Mr. Smith, on July 6, 1883. He had put his hand through a pane of glass whilst drunk, and cut his wrist. The ulnar nerve, the flexor carpi ulnaris tendon, one of the tendons of the flexor sublimis digitorum, and about two-thirds of the median nerve were divided. The tendons and nerves were sutured with catgut, and the wound was dressed with carbolized oil lint and placed on a splint. At the time of the accident there was complete anæsthesia of the little finger, the ring and middle fingers, and of the ulnar side of the palm or surface of the thumb. Sensation in the index finger and the rest of the thumb was impaired.

9th.—The index finger and thumb were found to have fairly normal sensation in all parts. The palmar surface of the middle finger as well as the dorsal surface of its last two phalanges was anæsthetic. The radial side of the ring finger was also partially anæsthetic. The ring and little fingers on their palmar surfaces were anæsthetic. On the dorsal surface the ring finger was anæsthetic, but the little finger normal.

11th.—He has very distinct tactile sensation on the front of the little finger, and localizes the touch of a pencil accurately. The wound is suppurating.

Aug. 7th.—Electrical examination: The muscles of the ball of the little finger do not appear to have any faradic contractility. The wound is very nearly healed, and there is no further change.

Nov. 26th.—Sensation: Thumb normal. Index normal, except on the extreme ulnar side, where, though he can localize, sensation is impaired. Middle: Sensation impaired back and front; cannot localize except over first phalanx, to which he refers all touches on other parts of the fingers. Ring finger in a similar condition to the middle. Little finger: He localizes accurately everywhere; sensation is impaired. Palm in similar condition to the little finger. He has tingling feelings all over the area of impaired sensation. Muscles: All the ulnar muscles are wasted, but he can use the opponens pollicis fairly well. There is a tendency to clawed hand and stiffening of the joints of the fingers. There are no other trophic changes.

Dec. 31st.—No material change.

Jan. 14, 1884.—Slight improvement in sensation.

24th.—The opponens muscle reacts to faradism.

Oct. 11th.—General condition of the hand much improved. He is at work as an engineer, and able to earn good wages. No pain except when the hand is cold. Sensation: Thumb normal. Index normal. Middle: No sensation on palmar surface or on dorsal surface of first and second phalanges. Ring and little fingers: He localizes at the back but not at the front. Muscles: Ulnar muscles of the thumb are wasted; interossei are slightly wasted. He can oppose and abduct the thumb. Electrical examination: The opponens and abductor pollicis react to faradism. No reaction of the interossei. The hypothenar muscles react to a strong faradic current.

Sept. 24, 1885.—Still further improved; the hand is strong and useful. He earns as good wages as before the accident. Sensation: Localizes everywhere on the ulnar side of the ring finger. The thumb and index are quite normal, but over the other fingers and the ulnar half of the hand he still has pricking sensations when touched. Trophic: The ulnar half of the hand sweats more when hot than does the radial half: it is not colder than natural. Motion: Has voluntary power over all the muscles, but there is some stiffness of the joints of the fourth and fifth fingers, and for some reason or other he cannot properly spread the fingers. Electrical examination: All the muscles of the hand, both ulnar and median, react normally to faradism and galvanism, but their electric excitability is diminished.

CASE XXVII.—*Primary Suture of the Median and Ulnar Nerves, followed by much improvement within nine months.*

Edward F., aged ten, was admitted into St. Bartholomew's Hospital, under the care of Mr. Marrant Baker, on Feb. 5, 1888. He stated that he had fallen and cut his wrist with a jug, which he was carrying at the time of the accident. On admission he was found to be suffering from a ragged wound two inches above the wrist, on the flexor surface of the right forearm. An examination under chloroform showed that the median and ulnar nerves had been divided, together with many of the tendons. The median nerve and the tendons were sutured with catgut, and the ulnar nerve with horsehair. The wound did not heal by first intention, and, though there was never much suppuration, it did

not finally close until March 15th. The parts supplied by the median and ulnar nerves were quite anæsthetic when the hand was examined directly after the injury.

On March 10th I found that the patient could feel and localize sensations readily all over the thumb, and on March 13th there was further slight return of sensation in the index and middle fingers, though the ring and little fingers remained anæsthetic.

In Nov. 1888, I again saw the patient, and found sensation very greatly improved, so that he could feel the touch of a pencil on any part of the fingers, and could readily and quickly localize his sensations. There was also slight return of power in the abductor and opponens pollicis, but all the interossei muscles of the hand were much wasted. The nails were ridged and fibrous, and the hand was colder than its fellow.

CHAPTER IX.

THE VALUE OF PRIMARY SUTURE OF NERVES.

CLINICAL facts must furnish the basis on which an opinion may be formed as to the value of primary nerve suture. It is useless to argue from any other than a clinical standpoint. The investigations of experimenters on animals of various kinds possess a value of their own, but the conclusions arrived at in this way cannot possibly be directly applied to man.

When we consider that after the section of the spinal cord of a pigeon there may be a complete restoration of continuity, when we are told that in a monkey three or four inches of nerve may be re-made in as many months, the absurdity of applying to man the conclusions arrived at by experiments is very obvious.

The cases of primary suture observed by myself, and described in the last chapter, may be summarized as follows :—

The *median nerve* was sutured on twelve occasions. Of these eight cases were successful, three were partially successful, and one was a failure.

The *ulnar nerve* was sutured thirteen times. Of these, five cases were completely successful; four cases were partially successful; three cases were failures. In one case primary suture failed, and a secondary suture seven months later was followed by complete success.

The *median and ulnar nerves* were sutured in two patients, with success in one case, and improvement in the other.

The total number of cases observed by myself thus stands at twenty-seven: fifteen of these were successful; eight were partially successful; four were failures.

In two of these cases union by first intention, without previous degeneration, ensued. In each case the median nerve had been divided. In some of the other cases some fibres appeared to unite by first intention, although the bulk of the nerve did not do so.

I have already briefly described the cases I have myself seen, and

do not propose to do more than summarize those which have been published, for the perusal of a large number of very similar cases is necessarily tedious and not sufficiently remunerative to most readers.

I have found much difficulty in summarizing the cases reported in medical literature, for in many the reports are too meagre, in others they are evidently inaccurate, and in some they are imperfect in important particulars. I have thus been compelled to classify a certain number as "doubtful successes," for although they are claimed as successful by their authors, it is not possible to accept them all in the absence of important details. It is of course probable that in the majority of these patients there was perfect recovery, but I have thought it more satisfactory to include in the "successful" class only those about which there could be no doubt at all.

The following list, I believe, includes practically all the cases recorded as late as the end of the year 1885, and I think they are sufficient for my present purpose:—

Of Primary Suture of the Median Nerve.

Successful	6
Doubtful successes	6
Partially successful	5
Failures	2
Result not stated	1
Total	20

Of Primary Suture of the Ulnar Nerve.

Successful	4
Doubtful successes	4
Partially successful	3
Failures	4
Total	15

Of Primary Suture of the Musculo-spiral Nerve.

Successful	4
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Of Primary Suture of the Radial Nerve.

Successful	1
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Of Primary Suture of the Median and Ulnar Nerve simultaneously.

Successful	2
Doubtfully successful	2
Partially successful	4
Failures	3
Total	11

Of Primary Suture of the Sciatic Nerve.

Partially successful 1

Of Primary Suture of the Peroneal Nerve.

Failure 1

Of Primary Suture of the Posterior Tibial Nerve.

Partially successful 1

*Total number of Cases of Primary Nerve Suture, recorded
up to December 1885.*

Successful	17
Doubtfully successful	12
Partially successful	14
Failures	10
Result not stated	1
Total	54

These, added to my own 27, give a grand total of 81.

Successful	32
Doubtfully successful	12
Partially successful	22
Failures	14
Result not stated	1
Total	81

Now at first sight it might seem as though such a summary as the above would give a very fair insight into the prognosis of cases of primary nerve suture. Yet I venture to say that in some respects it is unavoidably misleading. I well remember that, when, some few years ago, I first interested myself in the question of nerve suture, I was inclined to form a somewhat low estimate of its value. I saw cases operated upon, and I saw them frequently leave the hospital without any material sign of nerve union, and with deformities resulting from trophic lesions, from contracted and atrophied muscles, or from anchylosed and painful joints. I was told by surgeons that most of the cases operated upon were failures, and such indeed was my first impression.

Further investigations, however, soon placed matters in a different light. I found that in almost all of the hitherto recorded cases, nothing was noted of the state of the paralysed parts after a few weeks or months at the latest; and I therefore determined to keep my patients in sight, not for months, but for years.

And whilst thus engaged in watching those who had been more

recently operated upon, I also sought out other patients who had met with nerve injuries in past years. On examining many of the latter I found that, as might be expected, most of those whose nerves had not been sutured at the time of injury were but little improved. Others had gradually recovered. In some of the latter the nerve-ends had been sutured, in some this had not been done. But what most interested me was to find that, in many patients who had completely recovered, there had been a long interval of many months, or even of years, between the time of injury and the return of sensation or motion, and I saw at once that no case should be written down as a failure simply because the operation of suture was not followed by immediate success.

It was with this impression that I continued to watch the various cases that I met with, and I believe that there is no other class of surgical injuries which so well repay clinical observation. So little has been written of them that they are constantly supplying surprises. Each case has its own peculiarities, each runs its own course, yet there are certain general rules which apply to all, and enable the surgeon to speak with tolerable confidence as to the final results of cases of nerve injury which have been treated by primary suture.

If there is one fact more than another which stands out in the clinical histories of the patients who have been under my own observation it is that, after the failure of union by first intention, after trophic changes of many kinds, after complete atrophy and degeneration of the paralysed muscles, recovery may yet be complete.

Time is the great requisite in these cases. The surgeon and the patient must alike have patience, and, if the nerve-ends have been placed and maintained in accurate apposition, it is to *time* that the final result must be left.

Putting aside for the present the cases in which primary union occurs, I would refer to the period that elapsed in my own patients between the time of suture and of repair.

Of the six cases of successful suture of the median nerve, five months elapsed in the first case before any signs of union were apparent. In Case II. restoration of function occurred within a few months; in Case III., it occupied more than a year; in Case IV., about a year; in Case V., about six months; in Case VI., there was no improvement for more than a year, and final restoration of function was not complete for one year more.

Of the five cases of successful union of the ulnar nerve, in the

first at the end of a year the hand was clawed, the muscles atrophied, the skin anæsthetic. It was not until *three years* later that restoration of function was complete and perfect. In the second case, as I have narrated, it was thought that the ends of the sutured nerve had become separated, and they were exposed, only to show an apparent union. The patient was discharged as a case of "failure," yet subsequently union took place.

In the third case three years elapsed before the cure could be said to be completed. In the fourth case, it was some fifteen months before the hand resumed its normal condition; and in the fifth patient, the time required for repair was more than two years.

In one case of successful suture of the median and ulnar nerves, the muscles were wasted, the hand was paralysed, cold and blue, and the skin was anæsthetic six months after the operation. In another year the hand was practically restored to its natural condition. The other case of suture of the median and ulnar nerves required two years before the functions were restored.

The facts are plain. When a nerve has failed to unite by first intention, its lower end degenerates, and again regenerates in the way I have already described. That such regeneration is hastened by contact with the proximal end I have no doubt, but in the cases in which the muscles have atrophied and degenerated it is evident that some time must elapse before they can be re-made. Motor functions, as a rule, take longer to return than do sensory ones.

Now, if it be conceded that years may elapse before return of function, it is evident that where the operation of suture has only been performed a few weeks or months, hasty conclusions as to the final result should not be drawn. Keeping this in mind, let us turn to the other cases that I have detailed and placed under the heads of "partial success" and "failure."

Of four cases of "partial success" after primary suture of the ulnar nerve, in the first case the hand was strong and useful, with almost complete return of sensation, when the patient was last seen, and improvement was still in progress three years and a half after the accident. Another patient died within seven months of the suture. The remaining two patients were seen and were still improving after intervals of two years and a half and one year and a half respectively.

Of three cases of "partial success" after median suture, one patient was seen in a much improved condition fourteen months

later, and both the others were also improving when seen respectively twenty-six months and two months after suture.

Of the four cases of "failure," in two the wound sloughed considerably. In the other two, after lengthened intervals no union occurred. To these I shall again refer in discussing the "causes of failure," and would now turn to the cases of primary suture described by other authors, and already tabulated.

Without stopping to consider the cases recorded as "successes," let us briefly glance at the length of time which the others—those of "doubtful success," of "partial success," and of "failure"—were kept under notice.

Of the cases of *median suture*, six, in which success was doubtful, were under notice respectively for two months, twenty-five days, two months, one month, a few days, and a few weeks. In five cases of "partial success" the times were eight months, a few weeks, several months, no time stated, and one month. In the two cases of "failure" no time is mentioned; the patients do not seem to have been under observation more than a few weeks at the outside.

Looking at the cases of *suture of the ulnar nerve*, we find that of four cases of "doubtful success" the patients were seen for periods of six weeks, eighteen days, no time specified, and five weeks. Of three cases in which there was "partial success," for two years, "some months," and one month. Of four cases of "failure," the patients were observed for three weeks, three weeks, one year and a half, and three weeks.

Of cases of suture of the *median and ulnar nerves*, in two, in which success appears doubtful, the patients were under observation for "some weeks" and a year and a half respectively. Of four cases of "partial success," for ten weeks, three weeks, fourteen days, and three months. In three cases of "failure" the patients were seen after six weeks, two days, and eight days respectively.

In the case of the sciatic nerve, the only patient was under notice for thirteen days, and there was then some improvement.

The only patient on whom a primary suture of the *peroneal* was performed died sixty-five days later with gangrene of the thigh. The nerve-ends were found separated.

In a case of primary suture of the *posterior tibial nerve*, there was a partial restoration of function in four weeks.

A consideration of these facts leads to the inevitable conclusion that the reports of these cases cannot be considered final. In the enormous majority of cases of failure or of partial success the time

that had elapsed since operation was far too scanty to allow of reunion, supposing that union by first intention had failed. I am convinced that it would be a most grave error of judgment to conclude that because no restoration of function had occurred, even as late as a year or more, that such was not possible. My own cases supply abundant proof of the correctness of this assertion.

Prognosis of Primary Nerve Suture.—In considering the prognosis of cases of primary nerve suture, there are two chief questions to answer: First, what is the probability of restoration of function? Secondly, how long will it take for function to be restored?

With regard to the first question my own mind is clear. *The probability is that function will be restored.* I am quite convinced that if the nerve-ends have been carefully coapted and kept in position, restoration of function will ensue in the great majority of cases. The instances I have given are my authority for this statement, for I have shown that in by far the greater number of failures, or of partial successes, the time which had elapsed when the cases were published was too short to permit of accurate conclusions being drawn. But, whilst I would thus give a good prognosis, I would at the same time warn the patient that some trifling inconveniences may remain permanently. Thus, in cases otherwise successful, I have noticed complaints of slight stiffness of the muscles or joints, of pains or aching when the weather changed, or when the parts were cold or wet. Other patients have complained that, though they had good tactile sense, nevertheless the parts felt, in a way that they could not explain, different from what they did before the accident; in fact, delicacy of both touch and motion are lost for a long time after power and crude sensation have returned.

The earliest signs of returning function are usually met with in relation to the sense of touch. The first thing the patient notices is that he can feel when touched in a part previously anæsthetic. Just at first he does not localize properly, perhaps refers sensations from one finger to the other, or from a finger to the palm of the hand. And indeed this is only what might be expected if we consider that the several divided nerve-fibres can never be united as before the injury, that the proximal end of a fibre which was distributed to the middle finger may become united to the peripheral end of one distributed to the thumb, and so forth. The patient has, in fact, again to *educate* his sense of touch in the way that all infants have to do. What has generally surprised me is the rapidity with which this education is completed, rather than

the difficulties which at first present themselves. The return of the sense of touch, followed by that of pain and of temperature, affords further ground for promising return of muscular power. Will the atrophied and shrunken muscles regenerate? (I am supposing some time has elapsed without improvement.) They will; their power will return, their bulk will increase. Trophic lesions also will disappear, and the tissues will practically return to their normal state. Do any general conditions influence the prognosis? I think they do. I am of opinion that the prognosis is better in the young than in the old, best of all in children and young adults. I think I have observed that regeneration is more rapid in warm summer weather than in the winter time, when paralysed parts are liable to become cold and livid, with impeded circulation and lowered vitality.

The consideration of these points leads directly to the second question in the prognosis—How long will it take for function to be restored?

This is not a question that can be answered directly. The first point for consideration is, What is the probability of union by first intention? For an answer to this I would turn to the cases already tabulated. In only two instances out of the seventeen under my own observation has union by first intention resulted. In each the divided nerve was the median. In three cases of suture of the ulnar nerve recorded by other authors—namely, Boëghold, Bramwell, and Clark—supposing the accounts to be accurate—there was union by first intention. In one case by Kraussold of suture of the radial, median, and ulnar nerves there was a similar result. Thus, out of a total of seventy-one, there are but six cases of union by first intention, and of some of these I am bound to confess I have some doubt, for there are absolutely no details supplied of those by Bramwell and Clark, and but few by Kraussold.

I should, therefore, conclude that union by first intention is not to be *expected* in any given case.

And, supposing that such union does not occur, what time must elapse before recovery? This is a question quite impossible to answer. It may be weeks, months, or years; no one can tell. Recovery may be preceded by trophic changes, joint disease and paralysis, or none of these may be present. But with regard to time I would not say more than that considerable improvement will probably occur within a year, and of this I would feel more certain in a young than in an old person. I would give up no

case as hopeless until the lapse of at least two or three years, and not then if any improvement was in progress. The age of the patient is a consideration of much importance. There can be no doubt that in young people nerves regenerate both more surely and more rapidly than in the old.

Does the prognosis differ in the case of different nerves? This is a question I have often asked myself. I think it does. All the cases of suture of the *musculo-spiral* have been successful, and, although it is looking ahead a little, I would remark that a similar success has attended almost all the operations of *secondary suture* in the case of this nerve. I should therefore be the more inclined to give a favourable prognosis.

In the case of the *median nerve*, I find that eight cases out of twelve seen by myself have been successful, while of twenty recorded by other authors only two are recorded as failures, and these may be explained by the short length of time they were kept under observation.

With regard to the ulnar nerve, my impression is that motion never returns before sensation, and that of all paralysed muscles the interossei are *the ones* which are most slow to recover. I have not seen a sufficient number of injuries of other nerves to form any opinion as to their relative capabilities of repair. Indeed, what I have just said in respect to the nerves of the upper extremity rather embodies my own somewhat vague impressions than suggests any definite conclusions.

Causes of Failure of Primary Suture.—I have already expressed my opinion that “if the nerve-ends have been carefully coapted and kept in position, restoration of function will ensue in the great majority of cases,” but I have no doubt that in some instances no such restoration occurs. The causes of failure are more than one, but those on which I would lay most stress are “sloughing of the nerve-ends” and profuse suppuration in the wound. The deleterious effects of sloughing are so obvious that I need not enlarge upon them. It is evident that if portions of the nerves are destroyed union is not to be expected. Thus, sloughing was the probable cause of failure in a case of ulnar suture at St. Bartholomew’s, and also in the case of suture of the peroneal nerve already alluded to. In cases where suppuration is profuse, portions of nerve may be destroyed by ulceration, and even if they escape this fate they are liable to be strangled and compressed by dense scar tissue, as in the case recorded by

Büsch-Madelung. But not only may the nerve-ends be destroyed by the suppuration, the sutures which hold them in apposition may likewise be liquefied, and thus the ends may become separated. I am inclined to think that this accident most probably occurred in the two cases of failure of suture of the ulnar observed by myself, but it is quite possible that pressure by scar tissue may have caused the continuance of the paralysis.

The Treatment of Cases of Failure of Primary Suture is sufficiently clear. In any case where a sufficient length of time has been allowed to elapse without restoration of function, the nerve should be exposed at the seat of injury. If its continuity is not interrupted, it should be freed from scar tissue, and then thoroughly stretched to free the individual fibrils yet more. If the ends have become separated from any cause, the operation of "secondary suture" should be performed as described in the following pages.

Treatment of Complicated Wound of Nerves.—In connection with this subject I shall allude but briefly to two complications. First, cases in which the nerve-ends are much lacerated and contused; second, cases in which the ends cannot be brought into contact.

With regard to the first, the proper treatment, in my opinion, would be the resection of such an amount of nerve as seemed too much damaged to recover, followed by stretching of the proximal and peripheral ends and fixation by suture. That the most satisfactory results may follow such treatment, a case I have already mentioned of a wound of the median nerve supplies ample proof. Here there was a great deal of laceration of the soft parts, and I found it necessary to remove about one inch of nerve which had been almost completely separated from both the upper and lower ends. I did not meet with any material difficulty in bringing the cut surfaces into apposition, and after fixing the hand in a flexed position on a splint, the case resulted in union by first intention.

The second complication I have mentioned is much more serious, for where the ends of the severed nerve cannot be brought into apposition on account of too extensive a loss of nerve substance, the prognosis cannot be very favourable.

Létiévant* has recommended that one of two operations should be performed. First, that the peripheral end should be grafted on to a freshened surface of some neighbouring trunk; or, secondly

* *Op. cit.*

that the proximal end should be split longitudinally to a sufficient extent, a cross section be then made of one-half of the nerve at the highest point to which the splitting is carried, and then that the split portion should be turned down and placed as a sort of graft between the parted ends.

I am not aware that either of these operations has ever been put into actual practice, but should view each with but little favour. The second suggestion especially seems to be of more than doubtful value, for the split portion would really be completely separated from each end, and in my opinion would probably slough.

In a case where an inch or two of nerve had been destroyed, and I was unable to bring the ends into apposition, I should pass sutures through them, and bring them as close as possible by the aid of stretching and of position. In this way further retraction would be prevented, and the two cut surfaces would, at any rate, be fixed in the same plane. I have already detailed cases in which union has occurred after excision of several inches of nerve independently of suture, and although I should not give a favourable prognosis, I believe that such treatment would afford the best prospect of recovery. In case of failure, however, or in cases where it is evidently impossible to get a satisfactory result on account of the amount of nerve destroyed, no time should be lost in performing the operation of nerve grafting, which is alluded to more fully at page 209.

Some experiments by Vanlair* are of interest in connection with the subject of separation of the cut ends of a nerve. This author details how he resected three centimetres of the sciatic nerve of a young dog, brought the ends as near to one another as possible with sutures, and enclosed them in one of Neuber's decalcified bone drainage-tubes. The wound healed readily, and four months later an examination of the seat of injury showed a reunion of the divided nerve. It is evident that the only value this treatment possesses is derived from the fact that the cut ends of the nerve are prevented from becoming adherent to the surrounding tissues, or compressed by the cicatrix; but there is also an evident disadvantage, namely, that such complete separation of the nerve-trunk from its surroundings is very likely to terminate in sloughing.

* *Archiv. de Phys.*, 1882, vol. x. p. 595.

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CHAPTER X.

SECONDARY SUTURE.

Secondary Suture of Nerves.—The operation of secondary suture is performed at some time after the infliction of the original injury, generally in cases in which no attempt has been made to secure primary union of the divided nerve. It may be performed either before the wound has healed, or else after it has cicatrized.

The indications for such an operation are afforded by the presence of symptoms pointing to the conclusion that a nerve has been divided and has not united. These symptoms I have already alluded to and described in detail, and will only point out that, as I have already insisted, it is not sufficient to examine the sensation alone of parts supplied by the nerve in question. The conditions and electrical reactions of the muscles are of as great, if not of greater, importance.

With respect to the advisability of performing the operation, I would say in its favour all that I have already said in connection with "primary suture." In all cases in which a surgeon believes that a divided nerve has not united, it is his duty to attempt the suture of the separated ends.

In performing the operation it is of prime importance that the parts should be as bloodless as possible, and to obtain this end the use of Esmarch's bandage is most advisable.

The limb having been rendered bloodless, an incision should be made through the scar in the line of the wounded nerve, the ends of which must be carefully sought. Very frequently these ends have become separated by a considerable interval, and it is frequently necessary to prolong the wound to a much greater extent than originally appears advisable. The upper end is usually the more easily found, for it is not atrophied, and its bulbous extremity is frequently very prominent. The latter is generally closely adherent to the surrounding scar tissue, and from this it should be carefully but completely separated.

The search for the lower end is sometimes very tedious and difficult. It is often much atrophied, and is liable to be displaced from its normal situation by contraction of the neighbouring scar tissue. When any difficulty is experienced, it is best to search for the nerve below the seat of section, and having found it at a place where it is not hidden or dragged aside, to trace it thence to the scar. From the latter it must now be separated in a similar manner to the upper end.

The extremities of the cut nerve having been thus exposed, the next question to arise is as to the *amount which should be resected*.

On this point my own opinions are very clear. The section of the upper end should be carried through the upper part of the bulb quite close to the normal trunk. At this point there are numerous young nerve-fibres, and the tougher tissue of the bulb affords an excellent hold for the sutures.

In dealing with the lower end, it should be remembered that its whole length is in the same condition of degeneration or of regeneration throughout. Manifestly there can then be no good done by cutting off successive sections in the hope that the cut surface may look more healthy than that which is seen on the first resection. All that should be done is to cut away the extreme end, which, being matted with fibrous tissue and compressed by the surrounding scar, is very likely to contain no nerve elements of any kind. It is seldom necessary to remove as much as a quarter of an inch, and, however unhealthy the section may look, no good is ever to be gained by a further sacrifice. The nerve-ends should be as little pinched or bruised as possible, and after section should not be held by forceps. If it is necessary to use the latter they should be fixed in the sheath.

In cases in which there has been much separation of the cut ends, an additional inch or more may be gained by a thorough stretching of each extremity. When this is to be done, it is often advisable to remove the Esmarch's bandage, for if it be applied immediately above the seat of operation, it will tend to greatly limit the amount of length to be gained by stretching.

As to the material for suture and the best method of passing sutures, I have nothing to add to that which I have written in treating of the subject of primary suture.

I shall again refer to the alternative treatment in cases in which the ends are so widely separated that it is impossible to bring them into apposition, and before entering any further into the

operation or the merits of secondary suture, I shall detail those cases which have been under my own observation, directing attention to any points of special interest that they may possess, and only drawing such conclusions as appear to me to be warranted by a careful consideration of their clinical details taken in conjunction with those of other authors. I have in each case appended the name of the surgeon under whose care the patient was placed.

CASE I.—*Smith.*—*Suture of Median Nerve four and a half months after division.—Success.*

Arthur B., aged twenty-three, was admitted into St. Bartholomew's Hospital on Feb. 8, 1882. He had sustained a severe cut across the wrist on Sept. 25th, and since then had lost the sense of touch in the thumb, and in the index and middle fingers. The backs of the second and third phalanges of the index and middle fingers and the extreme tip of the thumb were also anæsthetic. The opponens pollicis was paralysed. There were ulcers at the tips of the index and middle fingers.

On Feb. 8th, the median nerve was exposed by an incision at the side of the former injury and the upper end was found to be bulbous. The greater part of the bulb was removed, and a fresh section was cut off the lower end. The ends were then united by catgut sutures. On the 10th there was some return of sensation over the first phalanx of the thumb. On the 25th there was good sensation except at the tip of the index finger, and the wound was suppurating. In June he wrote to say: "I am very glad to tell you that my arm is all right, and that no more sore places have broken out since the operation. I can feel as well in one hand as the other, and one hand is as strong as the other, for I can go to work with it as if there had been nothing the matter. I find it a little colder in the mornings, but that makes no difference when I am at work."

CASE II.—*Marsh.*—*Secondary Suture of Median Nerve nine months after injury.—Return of motion before sensation—Partial success.*

Thomas M., aged twenty-four, was admitted into St. Bartholomew's Hospital on May 11, 1883. Nine months previously he had put his hand through a pane of glass and cut his wrist. There was a great deal of bleeding at the time, and he immediately lost

sensation in some of the fingers. He said he had not had much pain in the hand except in cold weather. He had burnt the fingertips and they had become blistered. He was unable to follow his occupation as a carpenter on account of the numbness of the fingers and thumb of the left hand. Five months after the accident the nail of the little finger gradually became ulcerated at the base, and after a few weeks fell off without at any time causing much pain. A new nail took its place. Present condition: Sensation of all kinds lost entirely over the last two phalanges of the index and middle fingers, both back and front, also on the palmar surface of the last phalanx of the thumb. Sensation is impaired over the radial half of the palm and ball of the thumb, and over the palmar surface of the first phalanx of the index and middle. The back of the thumb is quite natural. Sensation is impaired over half the ring finger. All the nails are quite natural. The fingers are cold. The muscles of the ball of the thumb are completely wasted. There is no power of abduction or of opposition.

May 15th.—Operation: The median nerve was found to be quite divided. The upper end was bulbous and retracted one inch from the lower end. The ends were refreshed and sutured with kangaroo tendon.

24th.—The wound has healed by first intention, but there is no return of sensation or of motion.

June 29th.—No material improvement except that sensation is rather more acute over the ball of the thumb.

July 31st.—No further improvement.

Nov. 26th.—The hand is much improved. The muscles which were paralysed are greatly increased in bulk, and he has good power over them. He can oppose the thumb thoroughly, but there is no reaction of the opponens or abductor pollicis to either galvanism or faradism. Sensation—Middle finger: Can feel, and with difficulty can localize, the touch of a pencil on the palmar surface, but not on the dorsal. The tip of the finger is more sensitive than elsewhere. Index: Same as middle. Palm: Localizes well, but sensation is yet impaired. The thumb is much the same as the other digits.

March 28, 1884.—Sensation: Not materially improved. He says that when the weather is warm sensation is much better. The hand, however, does not feel colder in one part than another. No trophic changes. Muscles: Firm and well-developed, quite as good as in the other hand. His grip is firm, and he has good

power over the opponens and abductor pollicis. The opponens contracts to a strong faradic current, but its electrical excitability is yet much impaired. It is immaterial whether the current is sent through the nerve from above the point of injury, or applied directly to the muscles.

Oct. 6th.—Sensation has improved. He now localizes everywhere, but the hand still feels numb, and he cannot pick up anything with accuracy. On this account he is unable to follow his occupation as a carpenter, although to a superficial examination there seems to be no loss of sensation.

Sept. 22, 1885.—Further improved. The hand is now quite as strong as the other, and there seems to be complete restoration of muscular power. The electrical reactions to faradism and to galvanism are normal. Sensation has further improved, but he is not yet able to work well as a carpenter on account of the numbness which he feels in the index finger and the thumb.

In this patient the muscles improved with comparative rapidity, whilst return of sensation was slow, and only partial. I think that if this man had been a labourer he would have considered the operation a complete success, and indeed it was so as far as motor power was concerned. It was in his occupation as a carpenter that he found the greatest amount of inconvenience in consequence of his inability to pick up quickly such small objects as nails, screws, &c. For, although he could localize the touch of a pencil-point without difficulty, sensation was not perfect. A very careful examination alone revealed any imperfection.

CASE III.—*Walsham*.—*Secondary Suture of Median Nerve nine months after injury*.—*Extensive trophic lesions*.—"Causalgia."
—*Regeneration of nerve fibres in the distal end*.—*Improvement after operation*.

Elizabeth G., aged fifty-three, was admitted into St. Bartholomew's Hospital on Jan. 17, 1885. In October 1884 she fell and cut her wrist with a broken glass bottle which she was carrying in her hand. The wound was sewn up and the hand placed upon a splint. The wound healed in a month, but ever since the accident there had been numbness of the index and middle fingers and of the thumb, with great feebleness of the hand. Present condition: A transverse scar across the forearm an

inch and a half above the wrist-joint. The flexor tendons are adherent to and drag upon the scar. The whole hand is wasted, especially the ball of the thumb. The skin of *all* the fingers is livid and glossy, and superficially œdematous, the mark of a pencil pressed upon the skin remaining for a long time. There is an apparent absence of all papillæ. All the nails, including those of the ring and little fingers, are curved, fibrous, ridged, and striated. The thumb, index, and little fingers feel colder than the others. Sensation—Index: Back of the second and third phalanges anæsthetic. Palmar surface anæsthetic over the last phalanx. Impaired sensation over the first and second. Middle finger: She cannot localize, but can feel a touch on all the palmar surface, and on the back of the second and third phalanges. On the dorsal surface of the first phalanx sensation is normal. Thumb: Dorsal surface natural except for slight numbness around the nail. Palmar surface: Anæsthesia of skin over distal phalanx. Impaired sensation over the first phalanx. Palm of hand: On the radial half a touch gives rise to a sensation of pins and needles. The back of the hand is natural. The patient complains of a constant sense of numbness, and more particularly of burning pain (the “Causalgia” of Mitchell) over the radial half of the thumb, and the index and middle fingers. Muscles: Paralysis of the abductor and opponens pollicis, with much wasting. The whole hand is weak. Electrical examination: No reaction of the muscles of the thumb supplied by the median nerve to either faradism or galvanism, and the other muscles of the hand and those of the forearm act less powerfully than those of the opposite side.

June 23rd.—Operation: The median nerve was found quite divided beneath the scar, the ends being half an inch apart. The upper end was bulbous, the lower wasted. The nerve-ends were freshened and brought into contact, being sutured with four kangaroo tendon ligatures passing through the nerve. The *arteria comes nervi mediani* was large, bled freely, and was ligatured. Microscopical examination of the lower end of the nerve showed regeneration of the nerve-tubules, there being numerous bundles of nerve-fibres which, though of small size, were yet provided with a myeline sheath. Other bundles were composed simply of elongated nuclei and fibres. The arrangement of the bundles was not so regular as is ordinarily found in the normal nerve. On section, the bulb showed numerous small nerve-tubules surrounded by much fibrous tissue.

24th.—Distinct return of sensation on the palmar surface of the ring and middle fingers. She can almost always localize the touch of a pencil. No other change.

25th.—There is sensation on the dorsal aspect of the index and middle fingers, but localization is still impaired. A touch on the palm does not now cause a pricking sensation as formerly. Sensation on the palmar surface of the middle and index fingers is not so good as yesterday.

26th.—Wound dressed, it looks well. Sensation at the tip of the index is less than yesterday, but there is some return on the palmar surface of the thumb.

27th.—Sensation is quite lost in the index finger; the wound is suppurating.

30th.—Some return of sensation over the first and second phalanges of the index. Sensation in the thumb is almost natural, that of the middle good, except over the back of the last phalanx.

July 10th.—Discharged. No further change since the last note. The wound healed with but little suppuration.

Sept. 22nd.—No further improvement. Ordered to be galvanized and to use the hand, which is still much wasted and in the same trophic condition as before the operation. The burning pain continues.

Jan. 26, 1886.—Much improved. Hand more plump; skin less shiny; fingers less tapering; scarcely any pain. Finger-joints still stiff. Sensation much improved; she can localize everywhere the slightest touch. Muscles still paralysed.

Feb. 4, 1887.—Not much change, but the hand is more useful.

Nov. 1888.—A good deal improved. The sense of touch is much better, and there is some power in the abductor and opponens pollicis, both of which muscles also react to faradism and galvanism.

The trophic changes noticed in the hand of this patient were very marked, and extended to parts usually supplied by the ulnar nerve. They persisted for some time after operation. Although the ends of the divided nerve were completely separated, regeneration of the tubes in the distal extremity was considerably advanced. In this case we meet for the first time with the phenomenon of a sudden return of sensation immediately after operation, which afterwards rapidly faded, and left the fingers for a time but little better than before surgical treatment.

CASE IV.—*Holden.*—*Median Nerve divided in the forearm.*
Secondary Suture five weeks afterwards.—Improvement.

Samuel B., aged thirty, warehouseman, was admitted into St. Bartholomew's Hospital on Nov. 1, 1879. Five weeks before admission to the hospital the patient had sustained a wound in the middle of the forearm, dividing the median nerve. Sensation was abolished in the median distribution.

8th.—The operation of nerve suture was performed. The nerve-ends were found half an inch apart, the upper being bulbous and united to the flexor sublimis digitorum. The ends were refreshed and united by four catgut sutures.

13th.—There was slight sensation in the previously anæsthetic area.

21st.—The wound, which had previously been doing well, suppurated.

Dec. 4th.—Sensation in the fingers was perfect.

I have lost all further trace of this patient.

CASE V.—*Holden.*—*Secondary Suture of the Median Nerve five months after division.—Return of motion, but not of sensation.*
—Improvement.

Ellen B., aged thirty-five, was admitted into St. Bartholomew's Hospital on Nov. 21, 1880. Five months previously she had thrust her hand through a window and cut her wrist severely. This accident was followed by loss of sensation in the thumb, index, and middle fingers, and by partial paralysis of the hand. Upon examination there was found to be an oblique scar across the front of the wrist. It was tender on pressure. There was anæsthesia of the thumb, index, and middle fingers, most complete at the extremities, but sensation on the palm, although impaired, was not entirely absent. The tip of the index finger was partly destroyed by an ulcer. The opponens and abductor pollicis were paralysed; the middle finger was much inflamed and swollen; the tip was ulcerated and the nail was stunted.

Dec. 3rd.—An incision was made over the seat of the injury. The median nerve was found to be completely divided, the upper end being bulbous, the lower atrophied. Fresh sections were cut, and the ends were sewn together with catgut.

9th.—There was a good deal of tingling in the index and middle fingers.

12th.—The wound was almost healed, but there was no material improvement in sensation.

Oct. 17, 1882.—Hand well nourished; ball of the thumb nearly as large as on the other hand. Good grasp. The tips of the middle and index fingers are stumpy, the result of previous ulceration. The nails curved and stumpy, but not ridged or furrowed. Sensation is almost absent over the last two digits of the middle and index fingers. She has no sense of heat or cold over the same fingers. Sensation is only slightly impaired on the tip of the thumb, but over the rest of the palmar surface it is good.

March 27, 1884.—No material change. Muscles of thumb still plump and firm. Good voluntary power of opposition. No reaction to electricity. She said that during the last six months the hand had improved and did not feel so numbed.

July 9, 1885.—Still no further change. She says that the radial half of the hand occasionally is greatly swollen and painful. She is able, however, to use it.

The improvement after operation in this patient was most marked. The ulcerated places healed, the muscles of the hand resumed their normal bulk and power, and instead of a miserably wasted hand, useless for all purposes, the patient became enabled to use it for almost anything. It is noticeable that, as late as three years and nine months after the operation, electrical contractility had not returned. Even at this date the patient claimed that improvement was yet in progress.

CASE VI.—*Marsh.*—*Secondary Suture of Median Nerve seven months after injury.*—*Improvement.*

Louisa T., aged fifty-six, was admitted into Lucas Ward, under Mr. Howard Marsh, on Sept. 12, 1887, on account of a wound of the wrist received by thrusting her right hand through a window-pane seven months previously. An examination of the hand showed a scar about an inch and a half above the wrist, and beneath the scar could be felt a bulbous, tender swelling. The index and middle fingers were blue and cold, the phalangeal joints were stiff, the skin was shiny, and the nails ridged and fibrous. The muscles supplied by the median nerve were wasted

and paralysed, and the hand was altogether very useless and painful. Sensation was lost in all parts supplied by the median nerve.

Sept. 22nd.—The median nerve was exposed beneath the scar. It had been divided, but the ends were not much separated, and after resection were secured in good position by some kangaroo tendon sutures. The operation was not followed by any immediate improvement, although the wound healed by first intention, and on October 30th an ulcer appeared at the tip of the middle finger, and caused the destruction of the greater part of the pulp.

During the next year sensation improved much, but as the hand was still weak and painful, Mr. Marsh exposed the nerve at the seat of suture in Sept. 1888, only to find the divided ends completely reunited. He nevertheless freed the nerve from the surrounding scar tissue and stretched it.

CASE VII.—*Willett.*—*Secondary Suture of Median Nerve four months after injury, followed by sloughing.—Failure.—Abnormal nerve supply to abductor and opponens pollicis.*

Ann B., aged forty, was admitted into St. Bartholomew's Hospital on June 20, 1884. Four months previously she had cut her wrist with broken glass. Present condition—Electrical examination: There is slight reaction of the opponens and abductor pollicis to faradism and to galvanism. No reaction of degeneration. Sensation—Index finger: Palmar surface anæsthetic. Dorsal surface anæsthetic over the third and half the second phalanx. Ring-finger: Anæsthetic on the radial side. Middle finger: In same condition as the index, except that there is slight sensation over the palmar surface of the second phalanx. Slight power over the opponens and abductor pollicis.

July 1st.—Operation: The median nerve was found completely divided. It was united by kangaroo tendon sutures. Four of the flexor tendons were also found divided, and were similarly treated. The operation was followed by much sloughing, and the patient when discharged a month later was in no way benefited by the operation.

In this case, before the operation of nerve suture, an electrical examination threw some doubts on the presumed division of the

median nerve, for a few fibres of both the opponens and abductor pollicis reacted to electricity in a natural manner. As, however, the nerve was found to be completely divided, and as the reaction was not altered by resection, it must be presumed that these muscles were either supplied by a branch given off from the median in the forearm, or else by some other trunk. They continued to react even after the sloughing of the wound, in which it is almost certain that the nerve was destroyed.

CASE VIII.—*Langton.*—*Secondary Suture of the Ulnar Nerve four months after injury.—Success.*

Jas. P., aged twenty-six, was admitted into St. Bartholomew's Hospital on Nov. 29, 1883. On July 7th he fell through a window and cut his elbow. This injury was followed by complete loss of all sensation in the parts supplied by the ulnar nerve and by paralysis of the muscles supplied by the same nerve.

On Nov. 29th he was found to be in the following condition—Sensation: Little finger entirely anæsthetic. Sensation much impaired on the ulnar side of the ring finger, and over the back and front of the ulnar half of the hand. All the muscles supplied by the ulnar nerve are absolutely wasted, and the hand is clawed. There are no trophic lesions of the skin. He says he has burnt the tip of his little finger without feeling it, but that it healed readily.

Dec. 11th.—Operation: Incision at the seat of injury behind the elbow. The ulnar nerve was found to be completely divided, and the ends separated by an interval of half an inch. They were resected and brought together by kangaroo tendon sutures.

On Dec. 12th (twenty-three hours after the operation) he said that he had a “tingling and pricking feeling in the fourth and fifth fingers since four A.M., and they feel as if they had more life in them.” There is distinct return of sensation on the ulnar side of the little finger and a small part of the ulnar edge of the hand.

13th.—Further return of sensation. He can localize over the whole of the ulnar edge of the palm of the hand, which was previously anæsthetic, and also over the ulnar side of the little finger. There is much improved sensation in the ring finger.

During his stay in the hospital there was no further return of power or of sensation.

March 5, 1884.—The hand is much improved in power. He is able to return to his work. There is no further alteration in sensation. The muscles supplied by the ulnar nerve still appear to be completely paralysed, the increase in power of the hand being apparently due to other muscles.

April 28th.—Slight improvement in sensation on the ulnar side of the ring finger. No faradic contractility of any of the paralysed muscles, nor any return of voluntary power.

Sept. 22nd.—Sensation improved in the ring finger and in the palm. No better in the little finger. One of the dorsal interossei of the third digit reacts slightly to faradism. The hand is much stronger, and there seems to be some slight power in the interossei muscles.

March 28, 1885.—Sensation has improved considerably, but is not yet perfect. There is no contraction of the fingers and no clawing of the hand, which is useful and strong, but the muscles supplied by the ulnar nerve are wasted and do not react to galvanism.

Sept. 19th.—Very much improved. The hand is so strong and useful that he is able to earn the same wages as an engineer as he could before the accident. He can use the interossei and flexor carpi ulnaris. Electrical examination: All the muscles supplied by the ulnar nerve react to faradism, but not to galvanism. He localizes well everywhere, but says that a touch causes a sensation of pins and needles, and the little and ring fingers still feel numb.

Jan. 31, 1886.—Sensation practically perfect. Good power in the interossei and the hypothenar muscles. The former react to faradism, the latter do not.

Feb. 5, 1887.—Hand nearly as strong and useful as before the accident. The muscles supplied by the ulnar nerve all react to faradism, but none of them react to any galvanic current.

The rapidity with which sensation returned in this patient is very remarkable. There was certainly marked and permanent improvement, with ability to localize sensation within twenty-three hours, and, judging from the sensations of the patient, it is probable that the return was even more rapid. The restoration of motor power was, on the contrary, very slow, and was not materially improved until eighteen months after the accident. Then it became rapid, and the final result was most satisfactory.

CASE IX.—*Langton.*—*Secondary Suture of Ulnar Nerve seven months after injury.*—*Success.*

W. W., aged eighteen, thrust this hand through a window-pane in April 1882, and inflicted a severe wound just above the wrist-joint on the ulnar side. He did not divide the ulnar artery, but lost a good deal of blood; the wound healed in about five weeks. From the moment of the injury he was conscious of a loss of sensation on the inner side of the hand, and over the fifth and half the fourth fingers. For some time this numbness gradually diminished, but sensation has not improved during the last month or two. About eight weeks ago he noticed that the hand (the left) was thinner than its fellow, and though he has used it constantly, it has rapidly diminished in thickness since that time. He has suffered no pain, but burnt the tip of the little finger in the flame of a Bunsen lamp, without noticing the heat, a couple of months since; the wound thus caused healed rapidly.

On admission into the hospital on Nov. 21, 1882, his condition was as follows:—The whole hand is very much thinner than its fellow, the interossei are wasted and the metacarpal bones look very bare, the ball of the little finger is nearly flattened, as is also that part of the thenar eminence corresponding to the adductor and short flexor. The fingers are all nearly straight, but the last two are slightly extended at the metacarpo-phalangeal joints, and the two distal phalanges are slightly flexed; this deformity can be readily removed when the first phalanx is drawn a little forward. What attracts most attention on looking at the hand is the constant abduction of the little finger at the metacarpo-phalangeal joint; this digit is not in any way forcibly held in this position, but can be readily placed in contact with the next finger, though not by any voluntary power on the part of the patient, who cannot adduct it in the least. With regard to the movements of the hand and fingers, the loss of power of grasp is very noticeable, the patient being able to indicate only twenty-five kilos on the dynamometer with the left, and forty-five kilos with the right hand. There is no power to separate any of the fingers from one another, though the index can be fairly well adducted. Within the limits already defined, flexion and extension of all the digits is good. There is no evidence of any trophic lesions, with the exception that the skin over the dorsal

surface of the last phalanx of the little finger is smooth and shiny. Sensation good to all kinds of stimuli over the whole dorsum of the hand, and up to the joint between the first and second phalanges of the fourth and fifth fingers. Over the back of the second phalanges of one finger and a half he cannot differentiate the two points of a compass, but can localize tactile sensation except at the extreme tips, where there is no sensation to any stimulus. On the other side of the ring finger, contiguous to the fifth digit, there is a long narrow area, where there is no sensation to any stimuli, but on the front of the same he can localize, and distinguish heat and cold very well. The skin over the ulnar half of the palm and along the whole of the front of the last finger is quite insensitive to all stimuli. Here, however, I may draw attention to a very interesting fact in connection with the sensation of the hand; though there is no real cutaneous sensibility, and though slight touches are not felt at all, the patient is well able to feel and localize the situation of any firm pressure, which he says he "feels deep down, but not on the skin itself." This is evidently due to a certain amount of sensibility remaining in the subcutaneous cellular tissue, possibly through nerves conveyed along the blood-vessels, which, as I have said, were not divided by the original injury. The anæsthetic parts are considerably colder than the rest of the hand.

On Nov. 23rd an incision was made parallel with the course of the ulnar nerve, through the cicatrix. After much tedious search in some very dense cicatricial tissue, the nerve was found divided, with its ends completely separated from each other and lying upon different planes; the upper extremity was bulbous, but had attached to it a long tapering piece of connective tissue; the lower was not much altered, though perhaps it was rather thinner than natural. The bulb, which was large, having been almost entirely removed, and the lower end freshened, considerable traction on the upper end combined with extreme flexion of the wrist was necessary in order to bring the two ends into contact; sutures of catgut and horsehair were then inserted, the skin incision sewn up, and antiseptic dressings applied. The hand was fixed on a splint in a position of flexion.

25th.—Has suffered very little pain, no rise of temperature. Wound dressed and is healing by first intention. There is a *decided return of tactile sensibility* over the palmar surface of the hand, but not elsewhere.

27th.—Patient says that since yesterday he has been able to feel more on the palmar surface of the fingers than for some months, and on testing him carefully he is found to have good tactile sensation over the whole of the palmar surface of the fifth and also along all the previously anæsthetic patch on the side of the ring finger; he can localize the touch of a pencil-point well in these situations, but cannot feel heat or cold, or differentiate the two points of a compass half an inch apart, except at the tip of the fourth finger. Wound nearly healed.

29th.—Tactile sensation much improved; can differentiate the two points of a compass half an inch apart over the whole area of ulnar distribution, except on the palmar surface of the little finger. Pain sense tolerably acute. Thermal sense good over ring finger and palm, but not over little finger.

Dec. 4th.—Sensation much the same. Wound healed. The hand is slightly flexed towards the ulnar side. He has slight power of separating the fingers, but no reaction can be obtained by faradization of the interossei or muscles of the little finger; the latter is still abducted.

8th.—Much improved. Sensation to all kinds of stimuli is nearly normal over the ring finger and palm of the hand, also over the palmar surface of the first phalanx of the little finger, and the dorsal surface of the first and second phalanges of the same digit. Over the rest of this finger tactile sensation is fairly good, but there is no sense of temperature. The affected muscles do not yet correspond to galvanism, but the abduction of the fifth finger is less marked. A microscopical examination of the portions of nerve removed showed that the bulb of the upper extremity was mainly composed of nervous material. The lower end of the divided nerve had in it a few apparently newly formed nerve fibres arranged in no very definite manner.

After an interval of several months, the muscles previously wasted began to develop and to resume their natural functions. Their complete bulk, however, was not regained for more than another year, and only in April 1884 did they react to electricity. The hand at that time was in a perfectly natural condition.

As in Case VII., there was rapid return of sensation after the operation, but restoration of power was very slow. Nothing could be more marked than the extreme wasting of all the paralysed muscles, and the deformity of the hand, yet as time went on these

muscles, which seemed indeed to have quite disappeared, gradually developed anew, and finally resumed their natural bulk and power.

CASE X.—*Langton.*—*Secondary Suture of Ulnar Nerve four months after division.—Abnormal nerve supply of the interossei.—Success.*

Cecilia F., aged seventeen, was admitted into St. Bartholomew's Hospital on May 11, 1885. In the previous January she had pushed her arm through a pane of glass and cut her elbow on the inner side. Since that time she had suffered from numbness on the inner side of the hand and wasting of the hand and part of the forearm. Present condition: Scar two inches long on the inner side of the elbow. An unhealthy ulcer on the ulnar side of the palm and base of the little finger. The little finger and ulnar side of the palm feel cold. Sensation: Little finger absolutely anæsthetic. Ring impaired, but localizes fairly well. Hand anæsthetic on the ulnar side. Impaired sensation on the palm and on the dorsum over the fourth and fifth metacarpal bones. Muscles: Hypothenar eminence much flattened. Interossei not much wasted. The hand is not clawed. There is no retraction of the fingers. She has power over the interossei of the index and middle fingers. The muscles of the thumb supplied by the ulnar nerve are wasted. Electrical examination: No faradic contractility of the ulnar muscles of the thumb, of the flexor carpi ulnaris, of the muscles of the ball of the little finger, or of the two innermost interossei. The two radial interossei react normally.

11th.—Operation: The ulnar nerve was found to be completely divided opposite the site of the original injury. The upper end was slightly bulbous, the lower end a little atrophied. Fresh sections were cut of each end, that of the upper passing through the bulb. The ends were sutured with kangaroo tendon.

15th.—Has been tested daily. There is no improvement. The wound has almost healed. An examination of the nerve-ends microscopically shows absolute degeneration of the lower end. No axis cylinder. No myeline sheath. The bulb of the upper end contains numerous bundles of small nerve-tubules surrounded by masses of fibrous tissue.

16th.—The patient says that the little finger does not feel so numb. There is distinct return of sensation on the radial side of

the little finger in its whole length. She can localize the touch of a pencil-point anywhere. The wound has healed.

June 22nd.—Sensation not appreciably altered since 16th. Electrical examination: The conditions are the same as before operation. The two radial interossei still contract quite naturally. They appear to be supplied by some other nerve than the ulnar.

Sept. 17th.—Has improved greatly; the hand is more plump. The ulnar muscles contract feebly to the will. Electrical examination: Muscles of the ball of the little finger contract to a strong current of faradism, not to galvanism. Sensation: Ring almost natural. Little finger: Localizes well on the radial side, but the ulnar side is anæsthetic. Sensation is impaired on the palm and dorsum over the fourth and fifth metacarpal bones. Trophic: Has had a few sore places on the little finger; they have healed. The nails and skin are normal. The hand is strong and useful. She can sew and write, but says that the hand aches if used for long, and also in cold and wet weather. She continues to be galvanized once a week, and has been galvanized for the last three months.

Jan. 26, 1886.—Much improved. The hand is more plump, but there is no definite return of power in any special muscle. The grip, however, is good, and she can press 35 lbs. with a dynamometer as against 48 lbs. with the other hand. The flexor carpi ulnaris acts well voluntarily, and reacts normally to faradism and galvanism. The patient localizes well and easily everywhere, but there is still some numbness.

April 8th.—Sensation further improved. The affected fingers feel quite like those of the other hand, except when they are cold. The muscles have all recovered power and are no longer wasted. They all now react normally to faradism and galvanism.

Feb. 1887.—Hand quite well.

CASE XI.—*Langton.*—*Secondary Suture of the Ulnar Nerve nine months after injury.*—*Success.*

Rachel H., aged twenty-three, admitted into St. Bartholomew's Hospital, Aug. 3, 1883. On Nov. 20, 1882, she cut her arm on the ulnar side with a broken jug, and since then has lost sensation in the ulnar distribution. Present condition: A scar, two and a half inches above the wrist, extending over both the palmar and dorsal surfaces of the ulnar side of the forearm. Sensation lost over

half of the ring and all the little finger; also over the ulnar side of the palm and back of the hand. There is no sharp line marking the anæsthetic skin from the normal skin. The hand is much wasted. There is complete paralysis of all the muscles supplied by the ulnar nerve. No trophic lesions in the skin or nails.

Aug. 4th.—Operation: The ulnar nerve was found to be completely divided. The upper end was bulbous, the lower very little atrophied, though separated from the upper by an interval of half an inch, and adherent to the surrounding tissues. The ends were freshened, almost all the bulb being removed, and fixed in accurate apposition by five sutures of kangaroo tendon.

7th.—Has undoubted return of sensation in the ring finger, both back and front; also on the back of the little finger, though not at the tip. This condition was established within sixteen hours of the operation.

9th.—Can localize well over both the ring and little fingers. No further improvement until her discharge ten days later.

Nov. 23, 1883.—Localizes well all over the ring finger, and also on the tip of the little finger. Sensation is not quite so good over the rest of the little finger, for though she can feel a pencil-point everywhere, she does not always localize it accurately. There is but slight impairment of sensation over the back and front of the hand on the ulnar side. The muscles are still much wasted and paralysed. The hand is cold, but there are no definite trophic lesions.

Oct. 28, 1884.—No change in sensation. There is no evident improvement in the muscles, and they do not react to faradism or galvanism. She has been using, and continues to use, a stimulating liniment, and bathes the hand in warm water. The joints of the ring and little fingers are partially stiff, and the hand is clawed.

March 31, 1885.—The hand is much more useful. She has no pain, and works as a general servant. Ring and little fingers are clawed; index and middle less so. No further improvement in sensation. No return of muscular power. No reaction to electricity.

July 14th.—Sensation has much improved; there is now but very little numbness. The hand is much more useful, and she can work well with it. There is still some wasting of the interossei, but the muscles of the ball of the little finger are plump and firm and strong, with fair muscular power, and react normally to both faradism and galvanism.

Sept. 8th.—Still further improvement. She now suffers but little inconvenience from the hand. She has a good deal of power in the interossei, and they have increased in bulk.

Feb. 5, 1887.—The sensation is nearly normal in the affected area. The hand is strong. The hypothenar muscles react normally to faradism, but require forty-two cells to obtain a reaction to galvanism: A.C.C. > K.C.C.

In each of the last two patients the return of muscular power and development were slow, much more so in Case X. than in Case IX. In the latter case, indeed, a year and nine months after injury there was no appearance of any change in the muscles, yet after that date they steadily and rapidly improved.

CASE XII.—*Langton.*—*Secondary Suture of the Ulnar Nerve at the Elbow three months after injury.—Success.*

Caroline R., aged eleven, was admitted into St. Bartholomew's Hospital on Feb. 29, 1884. Three months previously her sister threw a knife at her. It entered her forearm on the ulnar side, two inches below the elbow, and passed completely through the limb. The arm had been numb ever since, and had become wasted; an ulcer had developed on the ulnar side of the wrist as the result of a burn which she did not feel. Present condition: No tactile sensation in any part of the ulnar area; complete paralysis of all ulnar muscles; wasting of all ulnar muscles and clawing of hand; hyperæsthesia on pressure over the first interosseous space.

March 4th.—Operation: Nerve-ends found in apposition, united by fibrous tissue. The ends were resected and sutured by kangaroo tendon.

6th.—Slight return of sensation at the tip of the ring finger.

10th.—She can feel in the palm of the hand and on the back, but cannot localize.

17th.—The hyperæsthesia of the first interosseous space has passed off.

18th.—Localizes over ring finger, palm, and back of the hand, but not over the ulnar edge of the same. No real tactile sensation in the last two phalanges of the little finger. She can feel but cannot localize over the first phalanx. No return of muscular power. Ulnar side of ring finger is hyperæsthetic.

Sept. 2nd.—Can localize on both the ring and little fingers,

though often imperfectly. Muscles still much atrophied. No electrical reaction. No trophic lesions. No voluntary power.

March, 1885.—No material change, but she uses the hand well, and suffers no inconvenience.

Sept. 25th.—Localizes accurately everywhere, but says that the ring and little fingers still feel numb and tingling. No return of muscular power. Muscles still much wasted.

Dec. 2, 1886.—Hand practically well. The muscles are in good condition, and contract strongly. Examined electrically: all the muscles react readily to faradism, but the hypothenar muscles alone react to galvanism, and then show marked reaction of degeneration, with slow and wavy contraction: A.C.C. > K.C.C.

CASE XIII.—*Willett.*—*Secondary Suture of Ulnar Nerve four weeks after a wound.*—*Success.*

Henry B., aged forty-seven, a wood-carver, was admitted into St. Bartholomew's Hospital on Feb. 28, 1885. On Feb. 6th he had cut his wrist with a chisel, and had immediately noticed numbness in the ring and little fingers and inner side of the hand. Present condition: Absolute anæsthesia of the parts supplied by the palmar branch of the ulnar nerve, slight wasting of all ulnar muscles, with paralysis. No trophic lesions. Electrical examination: Complete loss of faradic and galvanic contractility.

March 4th.—Operation: Ulnar nerve found to be completely divided, the upper end a little bulbous, the lower a little atrophied. Both ends were stretched. Fresh sections were cut, and almost all the bulb was removed. The ends were united by five catgut sutures.

5th.—Much pain; no improvement.

8th.—Decided improvement apparent to-day for the first time. He can localize everywhere except over the palmar surface of the tip of the little finger.

17th.—Says his fingers feel nearly the same as on the other hand.

26th.—Discharged from hospital. Sensation has practically returned in the previously anæsthetic parts. No change in the muscles.

July 9th.—All the ulnar muscles are much wasted and completely paralysed. The ring and little fingers are clawed, and there is some stiffness in their joints. Electrical examination:

No faradic or galvanic contractility. Sensation: Says that the fingers feel a little numbed, but he can localize everywhere, and there is but little loss of sensation. Trophic: Nails of little and ring fingers slightly striated. Ordered to be galvanized twice a week, and to use a liniment composed of equal parts of lin. sap. and lin. camph.

Sept. 21st.—No further improvement. He has not been galvanized, but has used the liniment.

Sept. 10, 1886.—Very greatly improved. The hand is plump, strong, and useful. The fingers show no tendency to claw, but are when extended a little separated from one another, and have hardly any lateral movement. Sensation is good, but not quite natural yet. Electrical examination shows that the hypothenar muscles react well to faradism, whilst the interossei hardly react at all. A very strong galvanic current is required to cause any contraction of the hypothenar muscles, but then the reaction is normal in quality: K.C.C. > A.C.C.

March 6, 1887.—Hand practically well. Has returned to his work as a wood-carver.

Rapid restoration of sensation was the most obvious result of this operation, but for nine months there was no change in the condition of the paralysed muscles, although subsequently restoration of motion and of sensation was complete.

CASE XIV.—*Willett.*—*Ulnar Nerve divided one year and eleven months ago.*—*Secondary Suture.*—*Lower end found regenerated.*
—*Success.*

Francis S., aged thirty-six, was admitted into St. Bartholomew's Hospital under Mr. Willett, on Dec. 1, 1885. The patient stated that twenty-three months before admission he cut the right wrist by pushing his hand through a pane of glass. Since that time he has suffered from paralysis of motion and sensation in the ulnar area. Present condition: Scar about one inch above wrist-joint. Muscles: Interossei and muscles of hypothenar eminence much wasted and paralysed. Hand clawed in typical manner. Electrical examination: No reaction of muscles supplied by ulnar nerve. Trophic: No important changes, skin on the little finger shiny, and joints slightly stiff. Nails normal. Has had no sore places on the fingers.

9th.—Operation: The ulnar nerve was found to have been completely divided, and the ends were separated and adherent to

scar tissue. The upper end was bulbous ; the lower end atrophied. The ends were refreshed and sewn with catgut. The upper section was carried through the bulb in its upper half. The hand was fixed in flexion on a splint.

10th.—Slight return of sensation in little finger at tip. The wound healed without suppuration, but as late as Jan. 11, 1886, there was no material improvement in motion or sensation, though the tip of the little finger retained its returned sensation. Microscopical examination showed numerous young nerve-fibres in the distal end. Many of them had a myeline sheath, and in some the nodes of Ranvier were well marked.

Sept. 1886.—Sensation : No sense of touch over both dorsal and palmar surfaces of last two phalanges of little finger. Can feel but cannot localize over the palmar and dorsal surfaces of the fifth metacarpal bone and the ulnar edge of the hand. Sensation much impaired over back of hand as far as the middle line, over the ulnar side of the ring finger, and the first phalanx of the little finger.

April 1, 1887.—Writes to say sensation is returning and hand improving.

May 30th.—Says the hand is very much better.

July 13th.—Writes : “ My hand is improving ; I find it gets stronger every day. It is rather slow, but I am thankful that it is not going back.”

Oct. 1887.—Writes to say that the hand has improved greatly, is almost as strong as the other, and the muscles have filled out as large as those of the other hand.

CASE XV.—*Willett.—Secondary Suture of Ulnar Nerve at the Elbow eight months after injury.—Improvement.*

W. M., aged thirteen, was admitted into St. Bartholomew's Hospital on Oct. 13, 1884. Eight months previously he had fallen on to some broken glass and cut his right elbow. Since the accident he had noticed loss of sensation in the middle finger and half the ring, and on the ulnar side of the hand. There was also some loss of power in the hand. Condition on admission : A scar behind the internal condyle ; the hand clawed. All the muscles supplied by the ulnar nerve much wasted. Electrical examination : No reaction to faradism or to galvanism of the muscles supplied by the ulnar nerve. The hand and arm ache in hot weather. Sensation : Little finger anæsthetic ; ring,

anæsthetic on ulnar side. Palm of hand: Sensation impaired on ulnar side. These parts are also much colder.

Oct. 21st.—Operation: The ulnar nerve was found to be completely divided, and the ends were separated half an inch: the upper end was bulbous, the lower not so. They were resected, and four catgut sutures passed through them. The operation wound at first seemed likely to heal by first intention, but it failed to do so, and suppuration continued for several days, the wound not healing finally till Nov. 18th.

On Nov. 3rd, for the first time, there was found to be a slight return of sensation on the ulnar side of the ring finger. He could localize the touch of a pencil on the two terminal phalanges.

Dec. 1st.—Discharged: no further improvement.

March 4, 1885.—Very slightly improved. Pressure on the ulnar side of the forearm caused referred sensation to the ulnar area.

Oct. 29th.—Little changed, but has return of voluntary power, and slight electric excitability of flexor carpi ulnaris.

Feb. 10, 1887.—No further change. The only evidence of any improvement in this patient was that the ulnar nerve was sensitive in all the forearm, and that there was commencing return of power and of electrical irritability in the flexor carpi ulnaris muscle.

CASE XVI.—*Willett.*—*Recent Wound of the Ulnar Nerve.*—*Secondary Suture on fifteenth day.*—*Rapid return of sensation after suture, with loss of sensation after suppuration was established.*—*Improvement.*

John S., aged thirty, was admitted into St. Bartholomew's Hospital on Feb. 23, 1885, suffering from an incised wound of the right wrist, dividing the ulnar nerve and artery and the flexor carpi ulnaris tendon.

24th.—Electrical examination: The interossei and other muscles react well to the faradic current; galvanic current, K.C.C. greater than A.C.C. No increased galvanic irritability. No voluntary power over any of the ulnar muscles of the hand. Sensation: Palm of hand on the ulnar side anæsthetic, over fourth metacarpal bone sensation is impaired. Back of hand: Over fifth metacarpal bone anæsthetic, over fourth metacarpal bone sensation is scarcely impaired at all. Little finger: Palmar surface anæsthetic, dorsal surface over second and third phalanges in similar condition; impaired sensation over the back of first phalanx. Ring finger

anæsthetic over the extreme ulnar side, and impaired sensation as far as the middle line of the finger.

26th.—Electrical examination: Interossei act well to faradism, A.C.C. equals K.C.C. No increased galvanic irritability.

27th.—No further change.

28th.—Electrical examination: Reaction of degeneration plainly marked in the third dorsal interosseous muscle, A.C.C. greater than K.C.C. In the other interossei A.C.C. equals K.C.C. There is marked diminution of faradic contractility.

March 3rd.—Reaction of degeneration well marked everywhere: A.C.C. greater than K.C.C. No increased galvanic irritability. To the faradic current there is only the faintest fibrillar contraction.

4th.—There is no reaction to faradism.

10th.—Operation: The wound, which had almost united, was opened up, and the ulnar nerve was found to be completely divided. The ends were separated about three-quarters of an inch. The upper end was scarcely, if at all, bulbous; the lower end was natural. Each was attached to the scar tissue, and from this they were separated. Fresh sections were cut, and the divided ends were put in apposition by five catgut sutures passing through the nerve. The cut tendon of the flexor carpi ulnaris was also sutured.

12th.—Wound dressed. Sensation partially returned in the little finger, the hypothenar eminence, and on the ulnar side of the ring finger. The patient can localize the touch of a pencil-point fairly accurately everywhere. He says that the fingers still feel numb, and not like the others.

15th.—The wound is suppurating: no further change.

18th.—More suppuration; almost all the regained sensation is lost.

24th.—The patient's hand is in the same condition as before the operation. The wound is healing.

27th.—Discharged.

July 21, 1886.—Localizes fairly well, except in the little finger. Has some return of power in the muscles supplied by the ulnar nerve, and the abductor minimi digiti reacts normally to faradism and galvanism.

Owing to the patient having given a wrong address he was unfortunately lost sight of. In his case there was a most rapid return of sensation after operation, but it almost all subsequently disappeared. I have headed his case one of improvement,

but it is not possible to give any definite statement as to the final result: he was not under observation a sufficient length of time. The distal end of the nerve was found in a state of degeneration, the myeline being segmented and the axis cylinders difficult to find.

CASE XVII.—Morrant Baker.—Secondary Suture of Ulnar Nerve four months after injury, followed by Epileptic Fits.—Failure.

Chas. T., aged twenty-five, was admitted into St. Bartholomew's Hospital on Oct. 12, 1881. Four months previously the patient fell on a basin and cut his forearm. There is a scar just above the wrist on the ulnar side. The fingers are slightly flexed, especially the fourth and fifth. There is loss of sensation over the fifth and half the ring fingers. The patient cannot fully extend any of the fingers. The hand is blue, and the interossei muscles are wasted.

Oct. 19th.—Operation: Nerve-ends three-fourths of an inch apart, the upper bulbous. The cut ends were refreshed and sutured with silk

29th.—The patient had an epileptic fit.

Nov. 4th.—He had another.

He was discharged on Nov. 22nd. The wound was healed, but there was no real improvement.

This is the only case on record in which the operation of nerve suture has given rise to, or been followed by, any complication. What relation the epileptic fit had to the injury I cannot say, but it appeared probable that the two stood in the relations of cause and effect. He had never previously had fits.

CASE XVIII.—Langton.—Division of Deep Branch of Ulnar Nerve. Suture after two months.—Rapid return and loss of sensation.

Thos. S., aged fifteen, was admitted into St. Bartholomew's Hospital, under the care of Mr. Langton, on Sept. 15, 1887, with the history that he had cut his hand with a broken bottle two months ago. Present condition: Complete loss of sensation over the contiguous sides of the ring and little fingers on their palmar surfaces. Inner side of little finger normal. Back of same digits normal. Anæsthesia over ball of little finger incomplete. Muscles: Wasting of interossei and of all ulnar muscles except abductor and opponens minimi digiti.

These latter two are alone not paralysed. Electrical examination: No reaction to faradism of paralysed muscles. To galvanism feeble, slow, and wavy contractions: A.C.C. > K.C.C. Abductor and opponens minimi digiti normal. There is a scar over the ball of the little finger just in front of the pisiform bone.

20th.—Operation: Deep branch of ulnar and branch to outer side of little finger found divided. Sutured with kangaroo tendon.

23rd.—Can feel on contiguous sides of fingers.

25th.—Sensation lost, wound suppurating. After this, sensation gradually returned, and the wound healed with but little suppuration.

Feb. 10, 1888.—Localizes well and accurately over all the previously anæsthetic area. No return of muscular power.

Sept. 28th.—Localizes well everywhere, but still has some numbness. Muscles wasted. No voluntary power or reaction to faradism or galvanism. Hand painless and useful.

CASE XIX.—*Willett.*—*Secondary Suture of Ulnar Nerve two months and a half after injury.—Much improvement in eleven months.*

John B., aged thirty-seven, was admitted into St. Bartholomew's Hospital, under the care of Mr. Willett, on Nov. 16, 1887. with the history that he had cut his wrist against the edge of a rotating metal disc on Sept. 12, 1887. An examination of the hand showed a scar just above the pisiform bone, and beneath it a tender swelling could be felt. The muscles supplied by the ulnar nerve were wasted and paralysed, and the skin supplied by the same nerve was anæsthetic. The affected muscles did not react at all to faradism, and to galvanism they only responded by a feeble wavy contraction, and showed the reaction of degeneration (A.C.C. > K.C.C.).

On Nov. 22nd Mr. Willett exposed the injured nerve, and found that it had been completely divided, the ends being separated about three-quarters of an inch. After being pared, five catgut sutures were passed, and good apposition of the cut ends was obtained.

The wound did not heal by first intention, and did not finally close till January 9th, when there was some return of sensation

over the hypothenar eminence and the first phalanx of the little finger, though not elsewhere.

After this date the patient was regularly galvanized twice a week, and on Nov. 20, 1888, I found his hand greatly improved in every way. He could feel the slightest touch in all parts of the previously anæsthetic area, and could localize his sensations accurately. The hand was slightly clawed, and the joints of the little finger were slightly stiff. The hypothenar muscles had increased in bulk, and showed a decided return of voluntary power. The interossei were still paralysed, and none of the muscles supplied by the ulnar nerve reacted to either faradism or galvanism.

CASE XX.—*Langton.*—*Ulnar Nerve divided seven months ago.*
Secondary Suture.—*Great improvement.*

Thomas B., aged thirty-three, was admitted on March 22, 1886. Seven months ago he wounded his forearm with a circular saw. Since then he has had anæsthesia and weakness in the parts supplied by the ulnar nerve. Present condition: Scar on inner side of forearm three inches above the wrist. Sensation: Little finger and skin over fifth metacarpal bone anæsthetic. Impaired sensation of ulnar side of ring finger and over fourth metacarpal bone, both back and front. Trophic: Nil. All nails normal. Muscles: Typical claw hand with wasting and paralysis of ulnar muscles of hand. Electrical examination: No reaction to faradism or galvanism in the ulnar muscles of the hand.

29th.—Operation: Ulnar nerve found divided, with a large bulb on the upper and none on the lower end. The ends were resected, and sutured with three kangaroo tendon ligatures.

The wound healed well, but there was no improvement worth mentioning by April 17th.

July 12th.—Writes to say no improvement.

Feb. 4, 1887.—Writes: "A little more strength in the hand, but no feeling in the fingers."

Oct. 1888.—Writes that the hand is nearly as strong as the other, that he can work well with it, and that it never gives him trouble except in cold weather. Has not yet got the "proper feeling" in the two fingers.

CASE XXI.—*Walsham.*—*Ulnar and Median Nerves divided two years and four months previously.*—*Ulnar sutured, Jan. 11, Median sutured, April 1, 1886.*—*Improvement.*

E. B., aged eighteen, was admitted on Jan. 5, 1886, under Mr. Walsham. He said that he had cut the front of his wrist by falling through a glass door in August 1883. The hand since then has been useless. Present condition—Sensation: Little finger quite anæsthetic. Ring: Complete anæsthesia over two last phalanges. Can just localize over first phalanx on back and front. Middle—Dorsal surface: Can localize everywhere, but sensation much impaired. Palmar surface: Can localize over third phalanx, not elsewhere. Index: Same as middle. Thumb: Palmar surface, anæsthetic.; dorsal surface, natural. Back of hand: Complete anæsthesia over upper half of fifth metacarpal. Partial anæsthesia over fourth metacarpal; rest of dorsum natural. Palm: Can localize a touch everywhere, but sensation is much impaired. Slight hyperæsthesia over lower part of hypothenar eminence. Electrical examination: No reaction to faradism or galvanism in any of the intrinsic muscles of the hand. The hand is clawed, the finger-joints are partly stiffened. There is a scar just above the wrist to which the flexors are attached. Above this scar the bulbous ends of the nerves are readily felt. The skin of the hand is shiny. The only nail which is fibrous is that of the little finger. No other trophic lesions. All muscles wasted.

13th.—Operation. The ulnar nerve was found to have been divided, the upper end being bulbous, the lower not. Proximal end stretched. Two catgut sutures passed through the nerve, and ends fixed in good apposition.

Feb. 3rd.—Had much pain after operation. The wound healed with little suppuration, and the patient was discharged to attend the electrical department for a month or two.

March 18th.—Readmitted. No improvement.

April 1st.—Operation on median nerve; which was found quite divided. A good section was made, and the ends were sutured with three kangaroo tendon ligatures.

May 3rd.—Discharged: to be galvanized. No improvement. Microscopical examination—Median: The peripheral end shows numerous young nerve-fibres, with well-marked medullary sheaths and axis cylinders, but a considerable part of the nerve has

not so regenerated. The bulb shows numerous young nerve-fibres.

July 13th.—Good tactile sensation and localization on palmar surface of thumb, but no other improvement. Has been galvanized. Ordered to use liniment, and to have the hand shampooed.

Feb. 3, 1887.—No sort of improvement.

Oct. 1888.—Writes: "The hand has improved, and looks healthier. The fingers are not yet straight, and when the tip of the thumb is touched it is felt in the tips of the middle and fore-fingers. The sense of feeling has improved, but is not like that of the other hand."

I examined the hand on Dec. 23, 1888, and found that the patient could localize sensation caused by the touch of a pencil on the index finger and the thumb. The hand was cold and the fingers partly flexed. He could pick up anything between his thumb and index finger, and could do his work as a machinist. The muscles of the hand were not so much wasted, and there was decided return of voluntary power in those supplied by the ulnar nerve. The muscles of the hypothenar eminence also responded well to faradism, but not to galvanism.

CASE XXII.—*Savory*.—*Secondary Suture of Ulnar Nerve ten months after injury*.—*Failure*.

John H., aged thirty-seven, was admitted into St. Bartholomew's Hospital, April 24, 1879. He had fallen through a window ten months previously, and received a cut over the internal condyle of the humerus. Sensation was impaired on the ulnar side of the lower part of the forearm, and abolished over the ulnar half of the hand and the little finger. The hand was clawed, and in a position typical of ulnar paralysis.

May 7th.—Operation: Ulnar nerve found to be completely divided, the ends one inch apart, the upper bulbous. the lower not so. They were sutured with catgut.

17th.—Slight return of sensation in the little finger.

June 6th.—Some sensation over the ring finger, but no improvement in the little.

Nov. 22, 1883.—There is no evidence whatever of union of the ulnar nerve. A scar with a deep-seated bulb is behind the

elbow, which is not tender or painful. Muscles absolutely wasted, and loss of power over all the muscles supplied by the ulnar nerve. Inability to completely extend any of the fingers, though all but the little finger can be extended passively. Sensation: Complete anæsthesia of the whole of the ulnar area. Trophic: The ulnar half of the hand is very cold, and the patient says it never sweats. The skin, hair, and nails are normal. A portion of the tip of the little finger has been destroyed by an ulcer. The patient says that he always has a numbing, tingling pain over the ulnar half of the injured hand, and says that a similar pain is always present in the corresponding half of the other hand, and is made worse by cold, &c., in proportion as the injured hand is affected. There is, however, no muscular wasting, no anæsthesia, and no alteration of the electrical condition of the uninjured hand.

CASE XXIII.—*Savory*.—*Secondary Suture of Musculo-spiral Nerve five weeks after division*.—*Success*.—*Return of motion before sensation*.

Joseph C., aged seventeen, was admitted into St. Bartholomew's Hospital on April 28, 1883. On March 25th he was stabbed in the arm with a cobbler's knife. The wound was dressed by a doctor, and a week afterwards the patient came to the hospital with the wound still open. As soon as the injury was inflicted the hand dropped, and has been partially paralysed ever since. Present condition: A small scar of a punctured wound on the outer side of the arm, three and a half inches above the elbow-joint. The scar is painful, the pain being referred to the radial distribution. There is complete paralysis of the extensors of the thumb, fingers, and wrist, with wrist-drop. Electrical examination: No reaction of extensors to faradism, good reaction to galvanism, but reaction of degeneration is well marked, the anodic closure contraction being greater than the cathodic closure contraction. Nutrition is good, and there is no material wasting. Sensation is impaired over an area which is sharply defined, and includes the back of the thumb, the dorsal surfaces of the first and second metacarpals, the lower half of the dorsal surface of the first phalanx of the index finger and a portion of the dorsal surface of the forearm on the radial side, and of the upper arm as far as the scar.

April 28th.—Operation: The musculo-spiral nerve was found completely divided, the ends being held in contact by some fibrous

tissue about a quarter of an inch in thickness. The ends were resected and stitched with catgut.

May 4th.—Wound suppurating. The arm is bandaged, and the condition of sensation cannot be estimated. He says he has had pricking sensations all night.

7th.—Slight return of sensation in the upper part of the forearm and back of the hand.

18th.—Can localize on the dorsum of the first phalanx of the thumb. No further improvement whilst in hospital.

July 13th.—No marked trophic changes. The hand is cedematous. No improvement in sensation. No return of muscular power, and no reaction to faradism.

27th.—No improvement in sensation. Slight power of extension of the wrist, but not of the fingers. No wasting. No trophic changes. The hand is straighter than formerly, and he can now do some work. The skin of the previously anæsthetic area is now hyperæsthetic to friction, which he says causes a feeling as if the arm was bruised, and makes the fingers tingle. The patient says he has frequent shooting and tingling sensations up and down the arm.

Nov. 16.—Much improved. Good extension of wrist and fingers, though not so strong as on the other side. Electrical examination: No contraction to either galvanism or faradism. Sensation improved, but still much impaired over the area which was originally anæsthetic. He has a boil on the arm at the outer margin of the anæsthetic area.

March 25, 1884.—The hand is quite useful. He is at his work as a boot-clicker. Sensation still but little improved since the operation. Muscles: Full power over the extensors, which are plump. The measurements are the same as those of the other arm. Extension movements are perfect. There is no faradic contractility, but after faradism the arm feels less numb. He has no pain, but the whole of the forearm tingles if the scar or the skin of the anæsthetic area is touched.

April 9th.—Arm strong and well. The previously anæsthetic area sweats much more profusely than the rest of the arm. He says he has no pain except when the arm is cold, and also from half an hour to an hour before rain. Electrical examination: The extensors of the wrist and of the thumb react to faradism and galvanism, those of the fingers do not yet react. He has been using a liniment of equal parts of lin. sap. and lin. camph.

March 27, 1885.—Muscles still perfectly natural. No change in sensation.

The result in this case was most satisfactory, for the paralysed muscles entirely recovered. The small amount of the hand supplied by the radial nerve is also well instanced, and the return of motor power before restoration of sensation is worthy of notice.

CASE XXIV.—*Langton.*—*Secondary Suture of the Median and Ulnar Nerves four months after injury.*—*Improvement.*

Charlotte W., aged eighteen, was admitted into St. Bartholomew's Hospital on May 15, 1884. On Feb. 15th she had fallen and thrust her hand through a window, and inflicted a deep wound on the front of the wrist, two and a half inches above the joint. Since that time she had lost sensation in the ring and little fingers, and the hand had become weakened.

May 15th.—Present condition—Sensation: Palm of hand: Not impaired on the radial side; no sensation on the ulnar side. Back of hand: Sensation good. Thumb: Sensation absent on the palmar aspect of the ungual phalanx, but good elsewhere. Index: Same as the thumb. Middle: No sense of touch except at the back of the first phalanx. Ring and little fingers are quite anæsthetic. Muscles: Wasting of the interossei and muscles of the ball of the little finger; also of the muscles of the thumb to a less extent. The patient has slight power of opposition of the thumb. Electrical examination: The opponens responds slightly to faradism, but none of the other muscles respond at all. The fingers are tilted backwards at the metacarpal joints. The hand is clawed. Trophic: The sore left by a burn is found at the tip of a finger. The injury was inflicted without her knowledge eight weeks ago. All the fingers are blue and cold.

16th.—Operation: The median nerve was found completely divided, and the ends separated one and a half inches. They were stretched, resected, and sewn with kangaroo tendon. The ulnar nerve was found partly divided, and sutured in a similar manner.

17th.—She says that the fingers feel better than before the operation, but there is no evident return of sensation. The wound healed, with some suppuration, and the patient went out on June 13th, but little improved in respect to sensation, and not at all in respect to the muscles.

Sept. 5th.—There is no improvement at all.

March 27, 1885.—The hand is worse, and is altogether in a miserable condition. The whole of the muscles supplied by the median and ulnar nerves are wasted and powerless. The three fingers on the ulnar side of the hand are blue, cold, and absolutely anæsthetic. All the nails are ridged and curved, but the index finger and the thumb are less affected in every way than the other three digits. The thumb is almost quite natural. Electrical examination: No reaction of any muscles in the hand. All the joints are stiff. The patient is to be galvanized twice a week.

Sept. 7th.—She was galvanized regularly for two months, and used a stimulating liniment to the hand. She is very greatly improved. Sensation almost perfect. Localizes everywhere quite readily. The hand is no longer so cold and glazed, the nails are less ridged, the finger-joints less stiff. The muscles of the hypothenar eminence as well as the flexor brevis pollicis act to faradism, but not to galvanism. She has some return of power in the same muscles.

Ordered to go on with the same treatment.

This case is to me one of great interest. Ten months after operation the hand was in about as wretched a state as could well be imagined, and anything more apparently hopeless I have never seen; yet—whether as the result of treatment or no I cannot say—in another six months improvement was so rapid that a happy termination might be confidently anticipated.

CHAPTER XI.

THE VALUE OF SECONDARY SUTURE OF NERVES.

THE value of the operation of secondary suture must be judged entirely from a clinical standpoint; for that reason I have thought it advisable to detail somewhat at length the cases I have myself observed, so that others might, as far as possible, be placed in possession of the facts which form a basis for the conclusions I shall venture to draw.

I have also appended a short summary of the cases recorded in surgical literature up to the end of the year 1885. These might easily have been supplemented by others of still more recent date, but they are quite sufficiently numerous for my present purpose; and, for the reasons given further on in this chapter, I do not attach so much importance to the results of published cases as I do to the study of those I have myself watched.

Cases of Secondary Nerve Suture occurring in St. Bartholomew's Hospital.

<i>Median Nerve.</i>				<i>Ulnar Nerve.</i>			
Successful	.	.	1	Successful	.	.	7
Partially successful	.	.	5	Partially successful	.	.	6
Failure	.	.	1	Failure	.	.	2
Total			7	Total			15
<i>Musculo-spiral Nerve.</i>				<i>Median and Ulnar Nerves.</i>			
Successful	.	.	1	Partially successful	.	.	1
Grand total			24				
Successful	.	.	.	.	.	.	9
Partially successful	.	.	.	.	.	.	12
Failures	.	.	.	.	.	.	3

Cases of Secondary Nerve Suture recorded in Surgical Literature.

Of Fifth Cervical Nerve.

Successful 1

INJURIES OF NERVES.

Of Median Nerve.

Successful	3
Partially successful	5
Failure	3
Total	11

Of Ulnar Nerve.

Successful	5
Partially successful	1
Failure	3
Total	9

Of Musculo-spiral Nerve.

Successful	11
Greatly improved	3
Failure	2
Total	16

Of Radial Nerve.

Successful	1
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Of Median and Ulnar simultaneously.

Successful	1
Partially successful	2
Failure	3
Total	6

Of Median and Radial simultaneously.

Partially successful	1
--------------------------------	---

Of Sciatic Nerve.

Successful	1
Improvement	1
Failure	1
Total	3

Of Popliteal Nerve.

Improved	1
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Giving a grand total of 49 cases, of which there were—

Successful	23
Partially successful	14
Failures	12

If the cases recorded by myself be added to those recorded by other authors, the totals will read:

Successful	32
Partially successful	26
Failures	15
Total	73

In drawing up the above summary of my own recorded cases I have been very careful not to include amongst the "successes" any but those in which there appeared to be either a complete, or almost complete, restoration of function. Many of the cases which I have only placed under the head of "partially successful," might, with almost equal fairness, have been placed under the first heading, and I have no doubt that in time they will deserve such promotion.

In the published cases recorded by other authors I have often had much difficulty in deciding whether to place the case under the "successful" or the "partially successful" class. I have, in cases of doubt, generally placed them under the latter; but where the details are but few, and where, as is often the case, the return of sensation alone is noted, it is impossible to accurately estimate the value of the individual operation.

But although I have taken all the care possible in this summary, as in that of cases of primary suture, this table, like the other, is misleading. The cause of error in each is the same.

Perhaps one of the first things that strikes one on a consideration of the cases noticed by myself, is the considerable *length of time* that frequently elapsed between operation and material improvement. More especially is this the case in connection with the *restoration of muscular power*. This is a point of such importance that I shall venture to still further analyse the reported cases.

Of my cases of secondary suture of the median nerve, in the case recorded as a success the latter was not attained for more than four and a half months after the injury.

In two of the cases of successful suture of the ulnar nerve, nearly two years elapsed before restoration of function was perfect.

In the other five cases the length of time required for repair was, respectively, one year and nine months, three years and six months, two years and nine months, two years and one month, and two years.

In the one case of suture of the musculo-spiral, power did not commence to return for three months, and almost a whole year elapsed before motor power was perfected.

In the cases of secondary suture in which successes have been recorded by other surgeons, the time that elapsed in several cases before complete restoration resulted was, respectively, one year, two years, a year and ten months, a year and a half, one year, two years, three years, one and a half years, &c.

In many cases a much shorter time was requisite, but the above instances are sufficient to show that, because restoration of power is not complete after a few months, this is no reason for considering the case a failure, or for supposing that further improvement will not take place. All that I have said on this subject when writing of primary suture applies here equally well; and I would now point out that, with these facts to work upon, a further investigation of the cases recorded by myself and others must result in the inevitable conclusion that, in many of the cases which are included amongst those of "failure" or of "partial success," a further improvement was to be expected, and would probably ensue.

Thus, if we look at the cases I have placed under the heading of "partial success," we shall find that, of my own, those of median suture were only under observation for nine months, eight and a half months, five-weeks, five months, and one year respectively. Those of ulnar division for a year and a half, two years and a half, and one year. That of the median and ulnar simultaneously, for one year and a half. Some of these patients are still under observation, and, from the way in which they have improved, and continue improving, I confidently anticipate a favourable termination. In the case of "improvement" in the suture of the median and ulnar nerves, there was no change for a year and three months, and then rapid restoration of power.

Seen in this light, the cases in which only a partial success, or else a failure, is recorded by other surgeons, assume a very different aspect.

Of the cases of "partial success," those of median suture were under observation for only twenty-six days, one year, several weeks, six weeks, and seven weeks respectively. That of ulnar suture, for five weeks.

Those of musculo-spiral suture for two and a half months, ten weeks, and two months.

Those of suture of the median and ulnar nerves, for seven months and for five weeks.

That of the sciatic for a doubtful time.

That of the popliteal, for three years.

Of the cases of "failure" recorded by other authors, those of median suture were kept under notice for eight weeks, "a few weeks," and in the third case for no special time mentioned.

Those of suture of the ulnar, for two months, a doubtful period, and for eight months respectively.

Those of musculo-spiral suture, for twenty-six days and for a "short time."

Those of suture of the median and ulnar simultaneously, for six months, three months, and a few months.

That of the sciatic nerve for one year.

Thus of all these cases of recorded "partial success" or "failure," but one—and that a "partial success"—was observed for more than a year, whilst most of the others were not seen for more than a few weeks after suture.

It is not possible to consider these results as final. I have shown that, in cases kept under notice for a sufficient length of time, recovery may ensue where failure has been expected. Of the cases that I record, most were discharged from hospital but little better than on admission; yet in almost all—in all, in fact, but two—improvement ensued at a later date.

Most of what I have just written is, as I said at the commencement, in reference to the return of *motor power*; and if we consider that at the time of suture the muscles were, in the majority of these cases, in a state of advanced degeneration and atrophy, I think that the long time required for restoration is only what might be expected. The nerve has to be repaired, and, after that, the muscle has to be remade. This restoration of muscle is indeed one of the most marvellous evidences of recuperative power ever met with in the human body. Muscles, of which there scarcely appears to be any remains, may be entirely restored in bulk and in power. It is wonderful that this occurs at all, and that it should occur rapidly is not to be supposed.

In the cases in which *sensation* returns, the most varying times are required for its restoration. In some cases there was restoration of sensation within twenty-four hours of operation, and in others within two or three days. In some, again, sensation did not return for many months; in others, it required a year or more for its further development. It is very noticeable that in some of my own cases, as well as in a few of the others, a rapid return of sensation after operation was followed by an equally rapid loss, after a few days of hope.

How is this rapid return to be accounted for? It has been noticed to occur at almost all times after section, at intervals of a

few weeks or of many months. For my own part, I do not doubt that it implies a restoration of continuity between the divided ends of injured axis cylinders. Either some of the latter have not entirely degenerated, or, as in the two cases of median suture observed by myself, they have again regenerated. This is, in my opinion, the only rational explanation. Some authors, on the other hand, believe that the return is due to some changes which ensue in the other nerve-trunks as the result of the section of the bulbous extremity of the proximal wounded end, though what these changes are they do not suggest, much less prove, and, for the present, at least, I shall continue to be sceptical as to their existence. It has been argued that it is not possible to explain restoration of sensation by a re-establishment of continuity of the divided axis cylinders if you do not find the said axis cylinders in the resected portion of the peripheral end. At first sight this appears plausible. It is certainly nothing more. My own experience of microscope work is by this time considerable, but I would certainly not be prepared to say that because I could find no axis cylinders in a tag-end about one-eighth of an inch long, therefore they did not exist. I can conceive nothing more difficult than to search for such remnants of nerve-tissue in the end of a wasted nerve mingled with the products of inflammatory action. The only rational explanation of a return of *power to localize* as well as to perceive sensation after secondary suture is that it is due to reunion of the divided axis cylinders.

How, then, shall we explain the not infrequent disappearance of the recently restored sensation? My own experience is that this disappearance is usually coincident with the establishment of suppuration or of inflammatory swelling about the wound, and I consider that in such cases the recently united nerve-ends become separated for the time by inflammatory exudation. This lost sensation may again return in a few days, and in time become perfected.

There is, however, another point of considerable interest yet to be noticed—namely, the rapidity with which regeneration sets in after the ends have been reunited. Looking at what we know of the changes occurring in the periphery of a divided nerve we might almost be led to expect that, in the most favourable cases, the nerve suture would but place the divided ends in a favourable position for union to occur after such a time as is required for the processes of degeneration and regeneration to be completed. But

the cases before us show very clearly that the reunion of the proximal and peripheral ends hastens most materially the reparative changes in the latter, so that instead of a year or more being required for the restoration of the nervous function this is often re-established within a few months of the operation, even when this has taken place months after the original accident, and consequently at a time when the peripheral fibres are supposed to be in their most degenerate condition. The exact manner in which this is brought about has not yet been demonstrated, but I should suppose that the increased rapidity of repair is simply due to the reunion of the nerve-fibres with their centre of nutrition. There can be no doubt that at the time of suture the nerve-fibres may be in an extremely degenerate condition, the myeline being destroyed and many of the axis cylinders absent, and yet that union may occur within the first twenty-four hours, as in the cases to which I have alluded.

Prognosis of Cases of Secondary Suture of Nerves.

—Speaking generally, I believe that the prognosis of cases of secondary nerve suture is that great improvement is almost certain to follow, and that complete success is to be expected in the majority of instances.

I believe that this prognosis is justified by the histories of the cases I have mentioned. Naturally, perhaps, I am influenced greatly by the conditions of the patients I have myself observed, and when I have seen one after the other improve, often after a year or two of paralysis and of deformity, I am inclined to think that if the nerve-ends are still in contact there is yet hope for all. I have already endeavoured to explain the occurrence of many of the reported cases of failure, and shall again refer to this subject. As to how long may be required for this restoration of function nothing definite can be said, but where there is great muscular atrophy the surgeon may feel sure that a really rapid restoration of power is a physical impossibility. I would give up no case until after several years.

As in cases of primary suture, I believe that restoration is both more rapid and more perfect in the young than in the old, that it is more rapid in warm weather than in cold, and that certain nerves—the musculo-spiral, especially—are more prone to unite than are others. I would refer for further evidence to what I have already said on the subject of primary suture.

In the case of secondary suture, however, a question has to be

considered that does not arise in the case of suture of recently divided nerves. It is, What is the influence of the length of time that elapses between the injury and the suture? I confess that, at first, I was disposed to think that the length of time exercised more influence than I am at present inclined to attribute to it. Nevertheless, I still believe that it may in certain cases materially influence the result.

As I have already pointed out, the peripheral end may be in varying stages of regeneration or degeneration at the time of suture, and though it might perhaps be expected that a corresponding difference in the rapidity of union could be established, and though I myself had expected to find such a difference, I cannot say that my expectations have been realized.

It certainly cannot be said that reunion follows more rapidly after suture performed a few weeks from the injury than after the same operation some months after section. Neither is the reverse true. I believe that a careful study of the recorded cases will show that, within at any rate the limits of a year, the time after injury at which suture is performed does not materially influence the subsequent rapidity or perfection of the union.

In one of my cases of secondary suture of the ulnar nerve, however, suture was not performed until after the lapse of two years, and the success which has followed in this case is, I believe, unparalleled in the record of cases hitherto published. In another case also of suture of the median and ulnar, the operation was not undertaken until two years and a half after the accident, yet in this patient there is partial return of sensation, of motion, and of muscular reaction to faradism. It is thus rendered certain that restoration of muscle and of muscular power, as well as return of sensation, may ensue on operations done as late as two years and a half after injury.

I have also quite recently seen a case in which suture of the ulnar nerve was performed twelve years after section. The patient was one of the students at St. Bartholomew's Hospital, aged twenty, and asked my advice as to the chances of success if an operation was undertaken. I told him that improvement was probable, that as the operation was trifling I should advise its performance, and ultimately persuaded him to come into one of the wards under the care of Mr. Howard Marsh, who sutured the nerve without any difficulty. At the present time, eight months after the operation, there is decided return of sensation in parts pre-

viously anæsthetic, and, judging from the rapid extension of the area of renewed sensibility, there seems good reason to hope for much more improvement. It is, of course, too early to expect improvement in the muscles, and a year or two must elapse before any final conclusions can be drawn.

Of the cases published by other authors, in one, suture was performed fourteen months after injury; the case is recorded as a failure, but the patient was only kept under observation for three months after operation, so this report cannot be considered final.

In one case the operation was performed after two and a half years. This again was a failure, but the patient was only observed for twenty-six days. In one case secondary suture of the sciatic was performed nine years after injury with slight resulting improvement. In one patient, whose case is recorded by Tillaux, a restoration of sensation followed suture of the median nerve fourteen years after injury. The case was reported seven weeks after operation, and no improvement in muscular power was noted. In the latter case it is important to observe that the peripheral end was much atrophied, and, further, that in the resected portions no nerve elements were found, though on the latter fact I do not lay much stress.

In another case, recorded by Sir W. Mac Cormac,* considerable improvement followed on suture of the ulnar nerve six years after its section, but the details of the case are unfortunately insufficient to allow of any very definite conclusions being drawn as to the ultimate result, and it is not stated for what length of time the patient was kept under observation.

Mr. Reginald Harrison has described a partially successful case of suture of the median and ulnar nerves after an interval of eighteen months, the state of the patient eighteen months after operation being described as follows:—He has resumed his employment as a groom, and can button his clothes and use a spade just as well as before the accident. The thumb can be fully and normally extended and flexed. The index, middle, and ring fingers cannot be fully flexed. The little finger is of no use, and is slightly and permanently flexed. Sensation is everywhere complete except in the little finger.

The question then arises, Will function be restored if suture is performed at any length of time after injury? That some

* *St. Thomas's Hospital Reports*, vol. xv.

restoration can occur in cases operated upon as late as twelve years after section I can have no doubt, but the published cases of suture after one year, being only few in number, are scarcely sufficient, nor are indeed reported with enough detail, to allow of a definite answer. This much at any rate may be said: in no case has *complete* restoration of function yet ensued when operation has been delayed more than two years. That *complete* restoration is impossible even after many years I will certainly not pretend to say, but I may draw attention to certain facts which are, I think, opposed to such a belief.

In an earlier chapter I have given my reasons for believing that after the peripheral end has become regenerated, it may again degenerate if union with the proximal extremity does not occur. It is of course possible that, even after this, reunion with the proximal end may result in another regeneration, though such appears at least doubtful. At what period of time this second degeneration occurs I cannot say, and for my evidence in support of this theory I must refer to Chapter III.

But whilst a degenerate condition of the lower end may possibly prevent the success of secondary suture, there is another condition, altogether apart from that of the nerve itself, which has been overlooked by other writers, but which I think is of far greater importance.

In an earlier chapter I have described the changes which occur in the spinal cord after amputation, and have pointed out how Vulpian has shown that these alterations in the central nervous system seem to be dependent rather upon the section of the nerves than upon the amputation itself. Now the changes described include serious destruction and atrophy of various parts of the spinal cord, and more especially of the large motor cells. These cells are the trophic centres of the muscles, and when once they are destroyed, it is very doubtful whether they can again be reformed. For this reason I think that after many years of solution of continuity of a nerve it is most improbable that motor power can be at all completely restored by the operation of secondary suture. That there may be some return in sensation I can believe, and indeed the cases recorded above seem to put this question beyond a doubt, but further evidence is required before any definite time can be assigned beyond which suture is useless. Meantime, I would never refuse to perform the operation merely because theoretically a perfect result seemed improbable.

Causes of Failure of Secondary Nerve Suture.—

In dealing with the causes of failure of primary suture of nerves I have already stated my opinion that it is frequently due to sloughing or extensive suppuration of the wound. The same causes may also prevent success in secondary suture.

In the only case of secondary suture of the median nerve under my own observation which resulted in failure, the wound, and probably the nerve, sloughed. In those cases where there was much suppuration union was generally more tardy. In a case recorded by Mr. Pye of secondary suture of the ulnar, the cause of failure was found to be the compression of the nerve by scar tissue, and after the latter had been separated restoration of function was rapid. This case is quite analogous to that recorded by Busch-Madelung of a similar operation with a similar result for a case of primary suture of the musculo-spiral in which the functions were not restored.

The giving way of the suture may also undoubtedly cause non-union, and thus we find that all the causes of failure present in cases of primary suture may also bring about a similar result in those of secondary suture.

The treatment also of cases in which secondary suture has not resulted in union is similar to that which I have recommended in cases of failure after primary suture. The sutured nerve should be exposed. If its ends have become separated, they should again be sutured. If the nerve is compressed by cicatricial tissue, or is unduly adherent, it should be freed from pressure and stretched.

Treatment of Cases in which the Resected Nerve-ends cannot be brought into apposition.—In a certain number of cases of old nerve injury it is impossible to bring the ends into apposition on account of their extreme retraction. Such a condition is fortunately not a common one, for the operation of stretching, followed by careful attention to position, is usually sufficient to overcome the retraction. I have never seen it necessary to abandon an operation from this cause alone.

The question is, nevertheless, one of much importance for the few patients who may be in such an unfortunate position, and various remedies have been suggested.

First, there are the two suggestions of Létiévant, to which allusion has already been made in dealing with the question of

treatment of recent nerve wounds where much nerve substance has been removed by injury.

The treatment alluded to as recommended by this surgeon consists in either suturing the lower end on to the freshened surface on a neighbouring trunk, or else in splitting the upper end, and turning down a portion by way of a graft.

Although I do not think that such treatment is to be recommended in cases of recent wound, where by other means union may be obtained, yet I am not disposed to altogether condemn either of these methods in dealing with a case in which all attempts at union have failed, and in which the parts are left in a hopelessly crippled condition. Of the two suggestions I should prefer to practise the latter, as it does not involve any interference with neighbouring healthy nerve-trunks.

The next suggestion is that the space between the separated ends should be filled by "grafting" into it a portion of fresh nerve taken from an animal or from a recently amputated limb.

The operation of nerve grafting and transplantation has been experimentally performed by Glück and Johnson, and, according to them, with success.

As far as I am aware, there are only three cases on record of this operation having been performed on man for the relief of injury.

The first case is recorded by Tillemans.* The patient was a woman, aged twenty-two, in whom the median and ulnar nerves had been divided. On the operation for secondary suture being performed, the divided ends were found to be separated four and a half centimetres. The operator therefore grafted portions of a rabbit's nerves between the resected ends. Sensation began to return at the end of four weeks, and movement at the end of nine.

The other operation was performed by Kaufmann. In a case of paralysis of the musculo-spiral following on an injury to the nerve in an operation for removal of dead bone from the humerus,† Kaufmann practised on Dec. 28, 1880, the operation of nerve grafting. After having freed and refreshed the two ends of the musculo-spiral nerve there was left a separation of more than four centimetres. In order to fill the gap, he therefore transplanted a portion of the sciatic nerve of a dog. In the middle of the following

* *Berlin Klin. Wochs.*, June 8, 1883.

† *Rev. des Sci. Méd.*, vol. xxiv. 1884, p. 305.

February it was still impossible to pronounce on the result of this operation.

On Jan. 25, 1889, Mr. Mayo Robson showed, at a meeting of the Clinical Society of London, a girl, aged fourteen, on whom he had performed the operation of nerve grafting. The case was one of a neuroma growing on the median nerve in the lower third of the forearm, and necessitating for its removal the excision of two inches and a quarter of the nerve. Into the gap thus made Mr. Robson transplanted, forty-eight hours later, a portion of the posterior tibial nerve from a recently amputated leg, and in thirty-six hours there was some return of sensation. When the case was shown some four months after the operation sensation was almost entirely restored, and the patient localized a touch quickly and certainly, but acknowledged, on being asked, that the index and middle fingers did not feel quite like the others. The opponens and abductor pollicis were also much wasted, but not quite paralysed, and a small bulla had recently formed on the index finger. The case, nevertheless, was a most encouraging one, and bid fair to become a complete success.

In another case, operated upon by Bergmann, the separation of the divided end was overcome in another way—namely, by resecting a portion of the humerus, and so shortening the arm.* The patient was a lad, aged fifteen, who had been severely wounded in the right upper arm by a circular saw. The wound had healed in about ten weeks, but the boy had lost all power of motion, and all sense of touch in his right arm and hand. An operation was performed, in which the divided nerve was exposed, and it being found impossible to bring the ends together, two inches of the humerus were resected. The case has not yet been recorded by the operator, and it is not mentioned in the *British Medical Journal* which nerve was divided, or what was the result.

With regard to the best operation to perform in any case where apposition of the severed ends cannot be maintained, I am certainly of opinion that nerve grafting appears more likely to be beneficial than do the other operations, and in arriving at this conclusion I must confess to being greatly influenced by the success attained by Mr. Mayo Robson, who, as far as I am aware, is the first surgeon to perform the operation with human nerve, and that in a recently inflicted wound. I cannot believe that under any circumstances resection of bone is advisable, nor

* *British Medical Journal*, 1884, vol. ii. p. 1085.

do I think that either of the operations recommended by Létiévant hold out much prospect of success, and if I could obtain nerve I should prefer it infinitely to any other material which has been recommended, such as decalcified bone tube or catgut.

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 MIKULICZ : *Wiener Med. Woch.*, 1883, Nos. 39, 40.
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CHAPTER XII.

VARIETIES OF NERVE INJURIES.

UNDER the head of Varieties of Nerve Injuries, I propose to treat of the different ways in which nerves may be injured apart from section or laceration in open wounds. It will be found that there are many varieties of nerve injury, and although the symptoms of all have much in common, still there are many points of interest appertaining to each, and to these and their treatment I propose to devote the following pages.

Contusion of Nerves.—The pathological changes which occur in bruised nerves are somewhat difficult to determine. The effects of severe injuries of this character appear to be similar to those produced by section, whilst in others of less severity the conductivity of the nerve is only partially or temporarily destroyed.

Erb,* as the result of experiments, concluded that bruising of a nerve-trunk causes the same change in the white substance of Schwann as does section, but maintained that the axis cylinder remains intact in both the peripheral and central portions. He also described a thickening of the neurilemma at the seat of injury, caused by a collection of round and spindle cells, which he thinks interferes with the process of regeneration.

Tillaux† made experiments on nerves by striking slight blows with a hammer on the nerve-trunk. The result of such injuries was an extravasation of blood into the neurilemma and between the fibres, many of which, at the spot struck, were diminished in diameter, and on either side were irregularly dilated. In the course of a few days the Wallerian degeneration sets in, and the medullary substance degenerates, the axis cylinders also appear to be implicated in the degenerative processes.

* *Archiv für Klin. Med.*, 1869.

† *Affec. Chir. des Nerfs.*

According to Mitchell, after slight injuries, in which paralysis though temporary was complete, there was usually but little hæmorrhage, a few fibres were torn, "and a large proportion suffered simply a mechanical disturbance, which gave them for the time a baccated look," and irregularity of outline due to displacement of their semifluid contents. "If a nerve disturbed only to this degree be examined within a few days, when the paralysis is no longer discernible, the nerve-tubes present but very slight traces of mechanical alteration, and a still later inspection rarely shows greater alteration of the nerve save in a very few fibres."

"It is therefore probable that the condition described is one which is for the most part rapidly repaired, and that the temporary symptoms which follow slight nerve contusions may be due to the definite mechanical disturbance here spoken of."

More severe lesions break the fibres, and subject the entire tubes to the pressure of clots of blood, and to the destructive effects of compression by the material poured out for purposes of repair.

"In two of these cases artificially produced in the rabbit, the nerve-trunk became considerably enlarged, so as, in one case at least, to be fitly described as a neuroma."

It thus appears that the pathological condition of the nerve-fibres after bruising have been scarcely sufficiently studied to yield any very definite results. Nevertheless, Mitchell's observations, should they be confirmed, would supply an explanation of the symptoms following slight contusions; whilst in those of a more severe nature, I think there can be no doubt that Erb is scarcely correct in stating that the axis cylinder remains intact. It is difficult to believe that such can be the case when the skin and muscle supplied by the damaged trunk remain respectively in an anæsthetic and paralysed condition, and frequently undergo various trophic changes.

Contusions of nerves may, like other injuries, be slight or severe, and the symptoms resulting therefrom will likewise vary.

In the milder cases, the injury will immediately cause some pain at the spot struck, with tingling and numbing referred to the periphery, combined often with a subjective sensation of heat and flushing, which in some few cases really exist. These symptoms, as a rule, pass rapidly away, but in cases of somewhat greater severity the tingling, &c., remains for several days. In

others, again, the symptoms persist, and a condition of chronic neuritis, with neuralgic and shooting pains, is established, which, if not checked, will continue to spread, and be followed perhaps by one or many of the trophic lesions already described.

In cases of more severe injury, the contusion is followed by complete paralysis and anæsthesia of the parts supplied by the damaged trunk; a condition which may rapidly pass away, may remain for weeks or months before improvement sets in, or may become permanent. The prognosis is extremely difficult.

The following is a fairly typical case of severe contusion of a nerve:—

CASE I.—R. P., aged twenty-one, hairdresser, caught his arm in the travelling band of a machine; the limb was crushed between the band and the wheel round which it revolved, but though very severely bruised there was no external wound; the stress of the injury fell on the middle of the humerus. On admission to St. Bartholomew's Hospital, Jan. 19, 1882, the arm was powerless, the elbow could not be flexed, the wrist dropped, the fingers, with the exception of the little one, were motionless. Those parts of the forearm and hand supplied by the median and musculo-spiral nerves were anæsthetic. In the course of the next few days bullæ appeared on the index finger and along the radial border of the hand. He suffered but little pain. Till July 11th he was treated with galvanism twice a week. On that day I made the following note of his condition: Arm generally wasted. Circumference at elbow one inch less, and at the middle of the arm three-quarters of an inch less than on the opposite side. Forearm three-quarters of an inch less than its fellow. The arm hangs by the side, but can be abducted by the deltoid, and the elbow can be extended by the triceps. There is no power of flexion of the forearm, and wrist-drop is well marked. All movements of pronation and supination are absent. The thumb, index, and middle fingers are powerless, he can neither flex nor extend them; there is very slight power of abduction of the thumb. The movements of the ring and little fingers are fairly good. Hand and forearm distinctly colder than opposite side (about 6° difference between the two hands); though the day is very warm, the skin is blue and livid. The subcutaneous tissues appear œdematous and pit on pressure. The whole forearm, except the ulnar border and a small portion of skin

covering the lower and outer two inches of the radius, is absolutely anæsthetic; there is no sense of pain, heat, or temperature. The thumb, index, and middle fingers are in a similar condition. A small patch of skin over the ball of the thumb, close to the wrist-joint, has slight perception of touch. Over the radial half of the ring finger touch is impaired. The other side of the ring and the little finger are normal. The radial half of the hand, both back and front, is anæsthetic. The anæsthetic fingers are much colder than the fourth and fifth. He says they never sweat, and I cannot make them do so by the most vigorous friction, though the other hand is quite moist. Almost all the hair has disappeared from off the outer portion of the forearm and the dorsal surfaces of the first phalanges of the thumb, index, and middle fingers. That which is left is very short and stumpy. The nails are normal. The skin is not glossy or atrophied. He suffers no pain. There are several bullæ over the outer border of the first metacarpal bone, and over the dorsal aspect of the first phalanx of the index finger. The flexors of the thumb and index finger do not respond to galvanism, those of the other fingers do. The extensors and flexors of the wrist react very slightly. With regard to sensation, it is noticeable that, although he has no sense of touch, pain, or temperature in the parts above stated, he can feel, and can occasionally localize slight friction applied to the anæsthetic parts. From this date he was regularly galvanized twice a week, and directions were given that the arm should be well rubbed twice a day with equal parts of lin. ammoniæ and lin. saponis. Under this treatment he very slowly improved, and on Dec. 12th had regained much power in the hand and forearm, the skin of the hand also was not so cold and livid, and no eruption of any kind had appeared for the past two months.

April 20, 1883.—Nutrition of the arm much improved. Biceps and triceps both act fairly well. There is no power of extension of the wrist or fingers. No sensation in the palm or surface of the thumb or index finger, very little in the middle finger. The hair and nails are normal.

Dec. 4th.—Great improvement in the action of the biceps and triceps. They are nearly as good as in the other arm; otherwise there is no improvement. The biceps and triceps react normally to electricity.

March 5, 1884.—The whole arm is somewhat stronger, a con-

dition which appears to be due to increased power in the muscles supplied by the ulnar and by the musculo-cutaneous nerves.

March 26, 1885.—No further change.

Sept. 19th.—No material change, except that sensation in the middle finger has much improved. He says that the paralysed index finger sometimes twitches for several minutes at a time.

In this patient, then, after a lapse of three years and three-quarters, there was still almost complete paralysis of the parts supplied by the median and musculo-spiral nerves in the forearm. It is possible that these nerves had been completely crushed.

In the next case the injury was slight, and the recovery proportionately rapid.

CASE II.—*Contusion of Musculo-Spiral Nerve.—Exploratory Operation.—Complete Recovery.*

James S., aged sixteen, was admitted into St. Bartholomew's Hospital on Feb. 25, 1885, under the care of Mr. Willett, with complete paralysis of the extensor muscles of the forearm and of the supinators. His history was that three weeks previously he was thrown out of a cart, the wheel of which went over his right arm about halfway between the elbow and shoulder. He was at once brought to the hospital, and treated as an out-patient. The arm was kept at rest in a sling. From the time of the accident he lost the power of extending his wrist.

Feb. 26th.—Has complete wrist-drop, and no voluntary power over any of the extensor muscles of the wrist and fingers, or over the supinator longus. Sensation is but little impaired, there being slight numbness of the back of the right thumb. Electrical examination: No loss of faradic contractility in the extensors, which react also to a continuous current. No reaction of degeneration.

March 8th.—The musculo-spiral nerve was exposed in the upper arm, but was found to be perfectly normal in every respect.

15th.—The wound has healed; he is to be galvanized daily.

Sept. 30th.—The patient has entirely recovered both sensation and motion.

In this case the fact that the muscles supplied by the musculo-spiral nerve reacted almost normally to electricity, rendered it certain that there was yet continuity in the nerve-fibres them-

selves; but it is of interest to note that, although paralysis continued, yet the nerve when exposed showed no sign of injury. I have said that motion was entirely restored by Sept. 30, 1885, but within a month of the exploratory operation the muscles began to improve, and in two months the patient could work as a labourer.

Another injury, causing paralysis of one of the shoulder muscles, is of such common occurrence that examples of it must be within the knowledge of most surgeons. I allude to the paralysis of the deltoid which sometimes follows falls on the shoulder.

These cases, of which I have seen several, present much the same appearances, and their clinical histories are generally very similar. The patients are of various ages, and the injury is generally a fall on the shoulder. This is followed at once by partial or complete inability to raise the arm, and after some time by stiffness of the shoulder-joint and pain on movement.

An examination of the patient generally shows marked flattening of the shoulder and wasting of the deltoid muscle, combined with inability to abduct the arm and to perform any action requiring movement at the shoulder-joint.

On attempting to rotate the arm, or to extend it, considerable pain is caused, and an electrical examination shows impairment of contractility to both galvanism and faradism, though there is hardly ever absolute loss of reaction.

I think that these symptoms taken together leave but little doubt that the circumflex nerve has been contused where it passes around the humerus, and I should attribute the wasting and paralysis to this cause alone. The fixation of the shoulder also is, I think, to be accounted for by the fact that this articulation is supplied by the circumflex nerve, and I have already shown, in a previous chapter, that partial ankylosis often follows on nerve injuries. Most of these cases get well if the adhesions of the shoulder are broken down, and the wasted deltoid is treated by galvanism and shampooing.

In the following instance of contusion of the brachial plexus the injury was very severe and the amount of paralysis great. The injury to the nerves of the arm was complicated by a fracture of the humerus, but as the parts above the seat of fracture were paralysed as well as those below it, I do not think that the nerve injury was caused by the fractured bone, and do not therefore

include the case amongst those of nerve injuries caused by fractures.

CASE III.—*Injury to the Brachial Plexus, with complete Paralysis of the Upper Extremity.*

Thomas H., aged twenty-three, was admitted into St. Bartholomew's Hospital on April 18, 1883, under the care of Mr. Smith. On Nov. 8, 1882, he was struck by an engine on the right humerus. He was thrown forward, and the humerus and two ribs were fractured. He says that the hand and arm have been numb and useless ever since. Present condition: There is some callus at the junction of the middle and lower third of the humerus. There is complete wrist-drop. He can flex the wrist by means of the flexor carpi ulnaris, and can also flex the middle, ring, and little fingers. The flexor longus pollicis and the flexors of the index finger are paralysed. The biceps, triceps, coracobrachialis, and the deltoid are all paralysed. The muscles supplied by the ulnar nerve act well, as do also the thumb muscles supplied by the median nerve. Electrical examination: The lumbricales and interossei act well, also the adductor pollicis and the muscles supplied by the ulnar nerve, the pronator radii teres, and the long head of the triceps. The biceps, brachialis anticus, all the flexors supplied by the median nerve, all the extensors, the deltoid, and the greater part of the triceps do not react at all. The arm and forearm are wasted. There is anæsthesia of the skin of the whole of the forearm, except for a small portion on the ulnar side. The thumb, the index, and the greater part of the middle finger are anæsthetic. The ring and little fingers and the ulnar side of the palm of the hand are natural. The skin supplied by the circumflex nerve is anæsthetic. Trophic changes: The thumb and index finger are smooth and glossy; the base of the thumb-nail is ridged; the index finger and the thumb never sweat, and are colder than the other digits.

May 7th.—Under daily galvanism there is slight return of power in the biceps.

June 26th.—Has further improved. There is slight power in the triceps and biceps. He can extend the fingers, but not the wrist.

July 13th.—Still further improvement, although slight. Discharged.

Dec. 10th.—The biceps and triceps can be moved freely by

the patient, but react very slightly indeed to faradism. He has greatly improved in power in the upper arm, and can freely use the deltoid, though it does not react at all to faradism. The muscles supplied by the median and musculo-spiral nerves are quite paralysed. The ulnar muscles are normal. There is no change in sensation, but the hand is warm.

March 31, 1884.—No further improvement in sensation, but the muscles of the upper arm work well, are strong, and react to faradism. All the muscles of the forearm except those supplied by the ulnar nerve are wasted. There is no power of extension, but he can flex the middle finger and the last phalanx of the thumb. No faradic reaction of the muscles supplied by the median or musculo-spiral nerves. He is able to return to his work as a labourer.

Oct. 11th.—All the muscles of the upper arm are now natural. No further change except that the flexor carpi radialis, flexor longus pollicis, and the palmaris longus react to galvanism but not to faradism. The supinator radii longus also reacts slightly to galvanism and not to faradism.

July 12, 1885.—Further improved. All those muscles which previously reacted to galvanism alone now react to faradism also. The arm is stronger, and he is able to earn as good wages as before the accident. Thus, in this patient there was a very great improvement, which was continuous up till the time he was last seen, but whilst the parts supplied by some nerves steadily improved, those supplied by others, especially the median, showed but little alteration.

The following are examples of contusions of the brachial plexus in the neck followed by paralysis of irregular distribution, which in the course of a few months entirely passed away :

CASE IV.—J. C., aged twenty-five, was admitted into St. Bartholomew's Hospital, under Mr. Willett, on Oct. 8, 1886. The patient had fallen down a cellar and struck the lower part of his neck with much violence. On admission both upper extremities were found to be almost paralysed and partly anæsthetic.

Oct. 11th.—There was marked hyperæsthesia of the forearm, but the lower extremities were natural, the sphincters were not affected, and there was no evidence of injury to the spinal cord.

12th.—The left arm is better. He can lift it off the bed.

13th.—The hyperæsthetic condition is much less marked on the left arm and forearm.

15th.—The hyperæsthesia is limited to the right hand. He can now grip with the left hand, and can raise the right arm and forearm.

16th.—Can extend both arms and forearms.

22nd.—Can grip very feebly with the right hand.

From this time the patient steadily improved, being galvanized daily after Nov. 20th. He was discharged in December, and at the end of January had completely recovered.

CASE V.—W. M., aged thirty-eight, was admitted into St. Bartholomew's Hospital, under Mr. Savory, on Jan. 14, 1886, with the history that, on Oct. 26, 1885, he was thrown from a van and rendered insensible, and that on recovering his senses he found that he had lost the use of his right arm. A month later the hand and forearm were said to have become gradually numbed. On admission he was found able to flex and extend, and to pronate and supinate his forearm, and also to perform all the movements of the wrists and fingers, though every movement was very feeble. The deltoid was much wasted, and the power of moving the arm on the scapula was almost absent. All the muscles reacted very feebly to faradism and galvanism. The whole arm and forearm, except the parts supplied by the circumflex and the intercosto-humeral nerves, were quite anæsthetic. There were no trophic lesions, and the colour and temperature of the limb were normal. The patient was treated with small doses of mercury and by the daily application of the interrupted current. He gradually improved, and at the end of seven weeks was quite well.

CASE VI.—*Contusion of the Brachial Plexus in the Neck, with Paralysis of the Arm.*

William W., aged nineteen, was admitted into St. Bartholomew's Hospital on March 25, 1885. Three months before admission the patient had sustained a severe blow on the right side of the neck, through falling from a height. He was found on admission to have paralysis of the deltoid muscle, and partial paralysis of most of the other muscles of the arm and

forearm, also complete paralysis of the trapezius and of the levator anguli scapulæ and the rhomboids. There was very slight anæsthesia, of irregular distribution. Without any special treatment this patient gradually completely recovered. For three months he was galvanized daily.

On October 9 he was found to be quite well, and all the muscles responded to both galvanism and faradism.

The next case is one recorded by Lauth, in which the superficial cervical plexus and the upper cord of the brachial plexus were severely contused, with much resulting paralysis both of motion and sensation, but the patient subsequently completely recovered.

CASE VII.—*Lauth.—Contusion of the Fifth and Sixth Cervical Nerves, and of the Superficial Cervical Plexus.*

The patient was a man, aged thirty-five years, who was admitted to the hospital on April 10, 1884. On April 8, while lifting a piano into a cart, the whole weight of the instrument suddenly came upon the left shoulder. The clavicle was violently pressed backwards and downwards, and the neck was bruised. At the same time the patient felt a sudden loss of power in the arm. When admitted into the hospital there was found to be paralysis of the deltoid and of the infra-spinatus muscles, of the coraco-brachialis, of the biceps, brachialis anticus, and of the supinator longus. No other muscles of the forearm nor the triceps were paralysed. Sensation was abolished in the whole region of the shoulder, but in the arm it was not lost except in a part corresponding to the anterior portion of the biceps, probably to the portion of skin supplied by the cutaneous branch of the musculocutaneous nerve. On the forearm, sensation was abolished on the anterior surface in the upper part; behind and below it was normal. As to the hand, all the palm and the palmar surfaces of all the fingers retained their sensibility, but there was slight loss of sensation on the upper part of the thenar eminence. On the back of the hand there was some loss of sensation over the first and second metacarpal bones, and over the phalanges of the corresponding fingers. Besides these troubles of sensation referable to the nerves of the arm, there was found to be complete anæsthesia of all the region of skin supplied by the

superficial cervical plexus. There was no pain on pressure in the supra-clavicular fossa.

On the 14th of April it was found that sensation had returned on the back of the hand, and on the thenar eminence where, it had formerly been wanting. There was no other change in the paralysis or anæsthesia. On pressure there was considerable pain along the posterior edge of the sterno-mastoid, on the outer side of the deltoid, and on the anterior part of the biceps, also on the outer part of the shoulder and in the infra-spinous fossa. These pains, although localized upon the nerve trunks, appeared rather to be muscular than nervous. Electric contractility was slightly diminished, and the muscles were not atrophied.

On the 3rd of May there was distinct improvement in the movements and in sensation, electric contractility having never been abolished.

On the 8th of May flexion of the forearm was easy, and the supinator acted. The deltoid muscle alone still remained feeble. There were the same pains, but they were less marked. Sensation had returned in all the region supplied by the cervical plexus, and upon the shoulder it had returned in great part. There was only to be observed a small zone on the anterior part of the deltoid, which still continued anæsthetic. On the forearm sensibility had returned on the anterior and inner part; it was still wanting on the outer part as well as on the lower portion of the thenar eminence.

On the 30th of May the patient left the hospital, the cure being almost complete. There was only a slight feebleness of the deltoid, which did not prevent him from lifting his shoulder. Sensation had almost entirely returned; there remained a slight anæsthesia on the thenar eminence and the palmar surface of the last phalanx of the thumb.*

The two following cases are recorded by Sir James Paget,† and as they are good examples of a class of case differing a little from those already described, they will bear repetition :

CASE VIII.—“ A gentleman, subject to epilepsy, consulted me a few years ago. He was a strong muscular man, and in the two years before had had several slight and some severe epileptic

* *Révue de Chirurgie*, 1884, p. 560.

† *Medical Times and Gazette*, 1863.

seizures, and the slight ones were generally preceded by half a minute's mania. In one of these, a month before I saw him, he was seized by six labourers, who in their fright, and against his violent resistance, had held him down, and tied his feet and hands and arms with strong thin cords. The cords on his feet and body gave him only temporary trouble, but those on his arms and wrists did greater damage. They were twisted and tied as tightly as possible, and kept on for a long time. I think for some hours. The marks of some of these coils, in bands of bruised and brownish skin, were still distinct when I saw him. When he was set free his hands and wrists were powerless and insensible; he described them as "dropping," like those of one with lead palsy. Soon after the arms began to swell, and in the next four or five days they were in such a state of inflammatory œdema that it was expected that portions of them would slough, or that there would be extensive suppurations as with phlegmonous erysipelas. For three weeks after the injury he scarcely slept, on account of the severe pain in the injured parts. After the swelling subsided, which it did without suppuration, he began to regain slight power over the muscles, and slight and increasing sensibility of the hands; but at the same time, as well as perhaps during the swelling, a considerable wasting of the forearms and hands ensued, so that though they had been very robust, they now quickly became slender and puny. His general health suffered, but not severely. When I saw him his condition was greatly improved, and he seemed evidently recovering all that he had lost. His arms bore still the marks of the cords both above and below the elbows. All the muscles below the elbows were wasted, but the wasting was chiefly evident at the wrist, and most of all in the muscles of the ball of the thumb, and of the little finger. Both his hands were ready to "drop" when he raised his forearms, but he could just hold up his left hand, and in this he could just bring one finger to the thumb, &c. In this hand, too, he had regained sensibility enough to feel when and where any part of it was touched, but not enough to discern objects minutely. The hand had fairly regained its shape and size, but the skin of the fingers was smooth and glossy, and the cuticle of all the palmar surface had peeled. The right hand had recovered very little power; he could scarcely raise it, could hardly bring any finger to the thumb, and could hold nothing. Except in a few parts here and there, also, the skin of this hand was nearly, or in many places completely, insensible.

Both hands were occasionally the seat of pain, they were also very apt to become cold ; movement and pressure did not increase the pain. There was no displacement or injury of bones or joints, and no deep-seated disease could be felt. The general health was good and the pulses were natural."

CASE IX.—" Another case of a somewhat similar kind came under my notice some time ago. It was that of a lady, who, ten weeks before I saw her, when she was playing with some children, had fallen on her face, while she had her wrists tied very tightly behind her with a silk handkerchief. In her fall she pulled her right hand out from the handkerchief tied round the wrist, and in the instinctive efforts to release her hand and save herself from falling, she pulled with great force, at the same time that the pull was resisted by the silk handkerchief tied round the wrists just above the joints. No sign of displacement or fracture was found by the surgeon who saw her directly after the accident. The pain was not severe, nor was the hand quite disabled ; there was but slight ecchymosis and no indication of her having fallen on her hand, or struck it. But the hand remained after the injury very weak and very stiff, so that she could hardly move her fingers, and in all the distribution of the median nerve it was so numb that she doubted whether she could feel at all with it. Complete rest for the hand and arm were observed, warm applications, &c., were used. But when, at the end of five weeks, attempts were made to move it, and use friction and liniments, swelling took place about the back of the hand and fingers, and they became hot and red and glistening. The numbness no longer existed, but she had more pain and no ability of movement. The same state of things continued to the time at which I saw her.

" In both these cases much improvement has taken place. Two years after the accident the first of these cases was reported to me as much better ; and of the second the last note that I have (more than two years after the injury) is that the hand was much better, the thumb and forefinger could be easily brought together, and all the fingers had become much more moveable."

In the following case, by Sir J. Fayrer, the injury appears to have been severe, and the result unfavourable, so long as the patient was under observation :

A strong powerful man, an officer, received a severe blow on the arm from a large stone rolled down on him from a height, in the month of March. The arm was much bruised and swollen, and down to the fingers continued numb for a month; it then commenced to improve, the little finger first regaining sensibility. When he came under Sir J. Fayrer, in May, the limb was powerless and the muscles wasted, especially those above the elbow; it was colder than its fellow. The shoulder-joint was much relaxed, so that the head of the humerus appeared to be almost dislocated; there was no power of flexion of the forearm. He could swing the arm, and when it was supported in a state of flexion he could move the fingers and muscles of the forearm. Blisters, friction, and galvanism were tried, but by December of the same year he was not much improved, except in the movement of the fingers.

In his work on *Rest and Pain*, Hilton mentions having seen an officer who had sustained a severe bruise of the musculo-spiral nerve, sensation and motion not being restored for more than two years, but being complete in two years and a half.

In the following cases there appears to have been rather a sudden stretching of the nerve-trunks than a definite contusion, yet as the two conditions have much in common, I think it best to introduce them under the head of contusion, and not to treat them as separate conditions:

CASE X.—*Wrench of the Wrist, followed by immediate Loss of Sensation and of Motion in the Hand.*

Thomas M., aged fifty-two, was admitted into St. Bartholomew's Hospital, on Jan. 7, 1878. His hand had been forcibly bent backwards by a fall, and he had immediately lost sensation and motion in the hand. On admission there was paralysis of all the muscles of the hand, and almost complete anæsthesia. This was more marked on the palmar surface.

Jan. 10th.—Sensation has returned in the last two phalanges of the fingers.

11th.—Sensation has returned as far as the wrist. No return of motion.

18th.—Slight further improvement.

Feb. 1st.—Sensation is natural.

27th.—The hand is much improved in power and in sensation. He is able to use all the muscles, though they are not yet so strong as those of the other side.

CASE XI.—*Stretching of the Brachial Plexus by a sudden Wrench of the Arm.—Partial Loss of Motion and Sensation.—Complete Recovery.*

Lewis T., aged thirty-seven, was admitted into St. Bartholomew's Hospital, on Nov. 6, 1884. The patient was lifting a mass of machinery with another man, when his comrade slipped, and the whole weight was thrown on to his right hand. He immediately lost power in the right upper extremity. On admission there was almost complete paralysis of the arm and forearm. He could, however, close the hand, but the dynamometer only registered three kilogrammes on the right side, whilst it showed fifty on the left. There was pain over the clavicle in the region of the brachial plexus.

Nov. 10th.—Electrical examination: All the muscles react, though feebly, to faradism and galvanism. There is loss of sensation in almost the whole arm and forearm.

12th.—The dynamometer now registers eight kilogrammes on the injured side. Sensation has returned in the middle and ring fingers, and on the inner side of the hand and forearm.

13th.—There is slight anæsthesia of the thumb and index finger and the radial half of the palm of the hand. The skin over the posterior surface of the second metacarpal bone and over the forearm (except on the ulnar side) is anæsthetic. Sensation above the clavicle normal.

16th.—Further improved.

22nd.—He can now feel everywhere, but sensation on the thumb and index is still impaired. The dynamometer now registers twelve kilos. Under galvanism the patient got completely well in the course of a few weeks.

Symptoms of Contusions.—In examining patients who have suffered from nerve contusion, it is by no means uncommon to find that sensation and motion are not lost to an equal extent, that in some cases of complete paralysis of motion there is by no means a corresponding loss of sensation, and, much more rarely, that sensation is lost while motion is retained. The explanation that immediately suggests itself is that somehow either the

sensory or motor fibres, as the case may be, have escaped the injury from which their fellows have suffered. But it requires very little investigation to disprove this theory, and the intimate admixture of the two sets of fibres in the nerve-trunk (which can be proved by experimental section) demands another explanation. Some experiments by Leuderitz* throw light on this subject. He experimented chiefly on the sciatic nerves of rabbits, his method of procedure being to pass a ligature around the nerve, and then, drawing it to a certain degree of tightness, to note the results obtained by the application of the faradic current. His observations pointed to the conclusion that the conductivity of the motor fibres is always sooner impaired than that of the corresponding sensory fibres. In some cases all power of conducting motor impulses was absolutely destroyed, while the sensory function was unimpaired; the reverse was never the case. After removing the ligature in cases of complete motor and sensory paralysis, in some both faculties were restored at the same time, in others sensation appears to have returned, while the motor paralysis persisted. It is therefore assumed that sensory nerves possess a greater power of resistance than do the motor. The author quotes with approval the opinion of Duchenne, "That the prognosis of traumatic paralysis is much more favourable when, the electro-muscular contractility being extinct, muscular sensibility is unaltered, or but slightly diminished." In the above experiments, recurrent sensibility was eliminated by dividing all the other nerves of the limb.

These experiments certainly offer a fairly satisfactory explanation of many cases, while the theory of "supplementary sensation" is applicable to many others. The following is a good instance of loss of motion and sensation resulting from a bruise, and in this case, as in some of the experimental ones, the sense of touch was the first to return:—"A man, aged fifty-two, fell while carrying a heavy load on his head. His elbow struck the ground, and the weight came down on the palm of his hand with much force, bending it forcibly backwards. On admission to St. Bartholomew's Hospital, it was found that all power of movement was lost in the forearm and hand, and all sensation was gone from the elbow downwards. On the fourth day sensation commenced

* Published in the *Zeitschrift für Klin. Med.*, Band ii. Quoted in *Brain*, vol. iii.

to return, but it was not till a month later that he began to recover power, and at that time sensation was fairly complete. The cause of this return of sensation before that of motion has attracted the attention of many authors, and Létievant attributes it in all cases to "supplementary sensation." I think that this is not the case; it may be that, as the sensory fibres possess a greater power of resistance, so also they may possess a greater recuperative power. Or the ingenious suggestion of Mitchell may be correct. He thinks that the earlier return of sensation is due to the fact that, the terminal organs of the sense of touch being kept in a condition of constant stimulation, are more likely to return to their functional activity. "The skin is all the time stimulated, whether we will or not. The muscles which volition has ceased to move with ease have no such incidental stimulus. Accident and position do for the skin what artificial agencies must do for the muscles, if we desire to sustain their nutrition and restore their power."* Against this theory, however, is the fact that it is not only the muscles that are deficient in contractile power, but the motor nerve also will not respond to a current of electricity. It is a more likely explanation that a less perfect condition of nerve fibre is sufficient for the conveyance of sensation than is necessary for the excitation of muscular contraction; that is to say, that the amount of the stimulus required to produce a muscular contraction is greater than that requisite to produce a sensation.

The following case, reported by Mitchell,† is very important, and lends additional probability to the view I have above stated, that a less perfect condition of nerve is necessary for the conveyance of sensory than of motor impulses. I have already quoted from the history of this patient, so will merely give the following extract, premising that the median nerve had been divided for neuralgia fifteen months previously:

"In January 1877, Miss T. came to me, complaining of a return of all the old pains in the median areas. Sensation was partly restored, and I could move the median thumb muscles by galvanizing the main trunk above the line of section, although whether she could also affect the same by will was doubtful. It was but too plain that the median had partially re-made its mischievous connections. In May 1877, Dr. Bristow cut down on the median, and found large buttons as usual, but the filaments

* *Op. cit.*

† *Brain*, vol. i.

between were scarcely perceptible. Accordingly, I lifted the central portion above the upper button, wiped it dry, and put it on a piece of caoutchouc; then I faradized it gently, when the median thumb muscles all moved freely."

From the wording of the above, it appears certain that the patient had scarcely any, if any, muscular power, while she certainly had sensation, and it was proved that both motor and sensory fibres had united.

The general symptoms of contusion of a nerve-trunk are too sufficiently demonstrated in the cases I have detailed above to require any further comment. It now remains to consider the prognosis.

And here I would remark at the outset, that it is evident from the consideration of the clinical histories of patients suffering from nerve contusion, that we must be prepared to wait a very considerable time before repair can be expected, and the patient should at once be warned that he must not be disappointed if many months elapse before the paralysis of motion and sensation improves.

The evidence obtained by an electrical examination of the limb is of much value. If after the lapse of a week or more there is still faradic excitability of the muscles supplied by the injured nerve, we may feel certain that there is not complete solution of continuity of the nerve-fibres, that the injury is comparatively slight, and that repair will most probably be both rapid and complete.

In the larger number of cases, however, the faradic excitability rapidly disappears, and prognosis becomes more difficult. Attention should then be paid to the following points:—

First. Is the paralysis of all the muscles supplied by the injured nerve complete? If not, then the trunk is certainly not completely crushed, and the prognosis of a final recovery is good.

Secondly. Is the injury followed by rapid wasting of the affected muscles, and do they show the reaction of degeneration? If such be the case, then we may feel certain that there is complete solution of continuity of the nerve-fibres, though we cannot say whether the whole trunk, as such, is severed. In the cases, then, in which the paralysis is complete, the reaction of degeneration marked, and the muscles rapidly waste, we may be quite certain that, whatever the ultimate result, a long time—perhaps years—

will elapse before restoration of function ensues. We cannot say definitely that this restoration either will or will not take place, but I believe we may always say that some improvement will certainly ensue, even though it be after a great length of time. A consideration of the cases detailed above justifies this prognosis, for if reference be made to them it will be seen that, through keeping the patients in sight for some years, a gradual but considerable improvement was noted, even though many months elapsed without the slightest apparent return of power or of sensation.

Lastly. It must be borne in mind that the condition of the patient may progress from bad to worse. I do not think that in any given case such a contingency is at all probable, and I do not think that it could in any way be forecast. I shall again recur to this subject when discussing the course and causes of Neuritis.

Treatment.—The treatment of contusions of nerves is, in some respects, less satisfactory than that of complete division, for though, in favourable cases, the symptoms may rapidly pass away, in many others they persist in spite of all treatment; and in yet others, though some improvement may be effected, the case generally stops short of cure.

When the injury is of recent date, a few hours or days old, our efforts should be directed towards limiting and arresting the inflammatory conditions on which the symptoms may depend; with this object the part should be placed at perfect rest, and leeches or cupping may be resorted to with benefit, especially if there be much pain.

In other cases, where it is evident that the conductivity of the nerve has been entirely destroyed from the moment of injury, and where but little or no pain is present, antiphlogistic measures would be out of place.

Later on it is desirable to galvanize or faradize the paralysed muscles and anæsthetic skin, to apply vigorous and regular friction to the same parts, and to use counter-irritant liniments or blisters over a large extent of surface.

Should, however, symptoms of chronic neuritis supervene, and continue in spite of antiphlogistic or other treatment, I believe that the right and proper course to pursue would be to expose the nerve at the seat of injury, and ascertain its condition. It seems to me most probable that the continuance and spread of

the symptoms is frequently due to the formation of adhesions between the nerve and the surrounding soft parts, and to a gradual thickening of the nerve-trunk itself; and that if such a condition be found, the same is likely to be much benefited by the operation of nerve-stretching, which will free the trunk from the irritation and pressure of the surrounding inflamed parts.

CHAPTER XIII.

VARIETIES OF NERVE INJURIES—(*continued*).

Effects of Pressure upon Nerve-trunks.—In addition to the sudden and forcible compression to which nerves are subject, the symptoms of which have been included under those of contusion, the nerve trunks in different parts of the body are also liable to injury by more slow and gradual pressure directed either from within or without. The best experimental investigations on this subject are those of Aug. Waller,* Bastian, and Vulpian,† who exercised pressure on their own nerves, or on those of other human beings, the results obtained being of necessity much more satisfactory than any that could result from similar experiments on animals. The length of time over which the compression extended was from half an hour to an hour. According to these experimenters, the first symptoms consist of pricking and tingling sensations accompanied by feelings of numbness and warmth, which are not continuous, but liable to variation in degree and kind. These are followed by an hyperæsthetic condition of all the senses of touch, temperature and pain, with muscular twitchings, a state which is shortly followed by gradual loss of conductivity, as instanced by rapidly progressing anæsthesia, which soon becomes complete, and painful cramps of the muscles, soon succeeded by a state of complete paralysis.

When the pressure is removed the anæsthesia and paralysis last for a variable time, being dependent on the duration and severity of the compression; the senses of touch, pain and temperature then gradually return, being at first imperfect, and, subsequently, often hyperæsthetic, before resuming their normal condition. A subjective sensation of cold, and sometimes a feeling of a heavy superincumbent weight, is often present, combined with nausea, and, occasionally, syncope. Muscular power returns slowly, but the early movements are badly directed

* *Proceedings of Royal Society*, 1860–1862.† *Gaz. Médicale*, 1855.

and wanting in accuracy and power ; cramps are frequently present during this stage.

In addition to the experiments detailed above, Mitchell has investigated the same matter, by applying the graduated pressure of a measured column of mercury to the sciatic nerve of a rabbit, meanwhile testing the capability of the nerve to convey motor impulses by passing a current from a single "Smee cell." He says: "The communication seemed to be unbroken, and muscular movements could be thus excited till I had put on the nerve a pressure of twenty inches of mercury." Ten or twelve seconds of this pressure gradually lessened, and at last abolished, the power of the nerve to carry to the muscles the impression made by the galvanism.

"The tube was then lifted carefully, when to my surprise (and great interest) I found a gradual return of this power of transmission, although ten or fifteen seconds elapsed before the first visible manifestation occurred. These experiments, made chiefly on rabbits, and varied somewhat so as to place the nerve between two caoutchouc bags of mercury, gave on the whole the same general result. For the sciatic nerve, a few seconds—ten to thirty—of the pressure of a mercury column, eighteen to twenty inches high, broke the communication between two portions of nerve. Relieved from pressure, the nerve speedily recovered.

"It seems impossible to look upon this as other than a mere mechanical disturbance of the tubal contents, and a like mechanical restoration of their needed condition for activity.

"It is needless to speculate here on the very suggestive character of these observations in a physiological point of view. Pathologically considered, they are not less interesting.

"Remembering the delicate nature of the neural tissues, it seems inconceivable that twenty inches of mercury should not destroy them utterly. Moreover, what is the change that really takes place, and does it seem that the axis cylinders could be so broken as to refuse their office, and yet so unite in a few seconds as to be fit again for functional duty?

"From another standpoint the experiment seems to widen the breach between nerve-force and electricity, there being, as regards the latter, no analogy to this observation. I have made careful examinations of nerves which have been thus treated by compression. In all of them were noted some evidences of congestion, but the chief lesion lay in a very extensive disturbance of the contents

of the nerve-tubes. In some of them I could find scarcely an unaltered nerve-tube, the neural tissues looking much as they do seven or eight days after section. Yet through the nerve-tubes so disturbed, the nerve-force still has power to travel."

The question thus raised is no doubt a difficult one to answer satisfactorily, and the results of the above experiments rather lend probability to the theory that the nerves convey motor and sensory impulses by means of "vibration" of varying intensity. If this were true, it is very possible that a compression, not severe enough to utterly destroy the fibres, might yet so interfere with the vibrations of the molecules in the axis cylinders as to prevent the transmission of nerve-currents.

Such being the symptoms induced by compression, it remains to consider the circumstances under which we meet with such cases.

Perhaps the commonest cases of local palsy, induced by pressure, are due to the use of crutches. Instances of this are so common as to be within the experience of almost every surgeon; the class of patients most usually affected are those who are unused to artificial aid, and consequently are clumsy in their efforts towards progression; it is rare to meet with examples of this trouble in those who have long been in the habit of using crutches. The first symptoms are numbness and tingling in one or more fingers, followed by weakness and gradual loss of power in the arm and forearm. Sometimes one class of muscles is more affected than another, indicating pressure on one trunk in particular; the axilla is at times painful, and, if the patient persists in his endeavours to walk, complete paralysis of the arm will follow. The duration of the symptoms is variable; as a rule, sensation is less affected and recovers sooner than does the loss of muscular power; as some muscles are more affected than others, so do some recover more rapidly than others; the ultimate prognosis is favourable: such cases almost invariably get well.

Vulpian* records a case of crutch paralysis of both arms, the right being the more affected. Motion alone was affected. There was no paralysis of sensation, or of the vaso-motor nerves. As is often the case, the paralysis was not complete, some muscles being in a natural condition. Faradization of the musculo-spiral nerve produced no contraction of the triceps, but the application of the electrodes to the muscle itself readily produced contraction. This

* *Bull. de l'Acad. de Méd.*, 1882, No. 20.

reaction to electricity, Vulpian remarks, is analogous to that produced by curare, and he considers that the pressure must act by inducing some modification in the peripheral termination of the motor filaments. As the patient recovered, it was noticed that faradic contractility—the result of applying the electrodes to the musculo-spiral nerve—returned *before* voluntary power, a condition the reverse of that which obtains in recovery after section.

Symptoms very similar to those just detailed are liable to follow on pressure exercised on the nerves during heavy sleep. Such cases have frequently been attributed to exposure to cold, more especially by French writers (see Duchenne's works), but of late years this theory has been gradually abandoned. The numbness and tingling which are of common occurrence in cases where the pressure has been slight or of short duration, are familiar to most, but in others, which are by no means rare, the symptoms are more severe. These latter cases may result from pressure applied during natural sleep in bed, more often from the pressure of the arm on the back or arm of a chair, and sometimes from pressure applied during the heavy sleep of intoxication. As in crutch palsy, one or many nerves may be affected, and partial or entire paralysis or anæsthesia may be present. The cases in which entire paralysis of the upper extremity follows pressure applied during sleep are rather difficult to account for on the score of nerve compression alone, for it is hard to conceive that the whole of the nerves can be compressed during sleep in bed (yet I have seen such a case in a boy of twelve) sufficiently for the conductivity of all of them to be destroyed. In the face of this difficulty, it has been suggested by various physicians that interference with the circulation may assist in producing the results, though this is not my own opinion.

The prognosis at any rate is not so satisfactory as in the cases of crutch palsy, the symptoms are likely to be more enduring, for, while sensation is often recovered in a comparatively short space of time, the paralysis improves very slowly, and in some few cases is said to be permanent.

Other and rarer causes producing compression of the nerves of the upper extremity doubtless exist, but they are interesting rather as curiosities than from any special characteristics that they possess. The causes of such compression are most various. Mitchell* mentions cases arising from pressure

* *Op. cit.*

by weights carried so as to rest unduly on one portion of the arm, and from ligatures incautiously applied around the limb. Certain occupations tend to cause pressure on certain nerve-trunks. Thus, M. Bachon* records instances of extensor paralysis in water-carriers; and M. Ballet supplies the following instance in a glass-cutter.

Ballet.—*Paralysis from continued Compression of the Ulnar Nerve, due to Pressure while working as a Glass-cutter.*

A man, aged thirty-seven years, a glass-worker, who had worked at his calling for twenty years, noticed pain and tingling in the right hand. This he had noticed for fifteen or sixteen years. At his work he was in the habit of sitting with the right elbow resting upon the table on its inner side in a position in which apparently there was continuous pressure exercised upon the ulnar nerve. When the arm was at rest the patient felt no abnormal sensation, but when any pressure was made upon the elbow there was pain and tingling in the region of distribution of the ulnar nerve. There was no loss of sensation. There was some loss of power and atrophy in the interosseous muscles, but the other muscles were in a natural condition. There was also wasting of the adductor muscle of the thumb. Electrically examined, there was no reaction to faradism of the interossei or the adductor of the thumb. There was slight reaction to galvanism.†

The following cases by M. Panas have much practical interest, although the cause in each is of an unusual character.

Panas.—*Partial Paralysis of the Ulnar Nerve, due to Deformity of the Elbow in a case of Osteo-arthritis.*

The patient was a man, aged sixty-three, who had noticed weakness of his hand for twelve or thirteen days before he came to the hospital. There was but little alteration of sensation. The ulnar muscles were found to be partly paralysed, but were not wasted. An examination of the elbow showed that this joint was the seat of osteo-arthritis, and that an exostosis had grown backwards into the space behind the internal condyle and was pressing upon the ulnar nerve.‡

* *Rec. de Mém. de Méd. et Chir. et de Pharm. Militaires*, vol. ii. April 1864.

† *Revue de Médecine*, 1884, p. 366.

‡ *Archives Générales de Médecine*, 1878, vol. ii. p. 19.

Panas.—*Progressive Paralysis of the Ulnar Nerve caused by the Development of a Sesamoid Bone in the Internal Lateral Ligament of the Elbow.*—*Operation.*—*Suppuration in Elbow.*—*Death.*

The patient was a young peasant, aged nineteen, strong and in good health. He complained that for a year, without any cause and without any injury, his left hand had gradually become more and more feeble. An examination showed that the muscles supplied by the ulnar nerve were much wasted, and that the fingers were somewhat clawed. The deformity was typical of paralysis of the ulnar nerve. There was no alteration of sensation except along the ulnar side of the palm, where there was slight numbness and occasional tingling. Movement of the affected extremity caused pain. The muscles on the ulnar side of the forearm were also wasted. An examination of the elbow revealed a bony swelling situated near the inner condyle and evidently pressing upon the ulnar nerve. In this situation also the nerve was felt to be distinctly enlarged. An operation was undertaken for the removal of the bony growth, and after it had been exposed by an incision it was found to be situated within the internal lateral ligament of the elbow. In the course of the operation the elbow-joint was open, and some days later was the seat of suppuration, which resulted finally in the death of the patient. After death the swollen portion of the nerve was removed and examined microscopically. It was found to be thickened with fibrous tissue, and apparently in a state of chronic inflammation. The nerve-tubules had become irregular in size, their contents in places were granular, and they appeared to suffer by compression from the fibrous tissue which enclosed them*

Compression by Tumours.—The pressure exercised by tumours finds examples in almost every situation in the body, though of course more frequently in some parts than in others. The growth of aneurysms in the root of the neck and the popliteal space frequently causes pressure symptoms in the upper and lower limbs; the growth of cancerous glands in the axilla or groin, of exostoses from the last cervical vertebra, of lymphomatous or lympho-sarcomatous tumours in the mediastina, of thoracic aneurysms, and of various tumours in the triangles of the neck, afford numerous instances in which the symptoms of tumour pressure may be studied.

* *Archives Générales de Médecine*, 1878, vol. ii. p. 5.

Amongst rarer examples may be mentioned such cases as that of a bursal tumour in the arm causing pressure on the median nerve,* or that of a growth the size of an orange, compressing the sciatic. Many other exceptional cases might be quoted. The severity of the symptoms depends on the rapidity of the tumour growth, and the extent to which affected nerves are capable of being pushed aside rather than stretched over the surface of the swelling.

But perhaps the most common example of an innocent tumour causing symptoms by pressure on nerve-trunks is afforded by the cervical exostoses which are frequently found arising from the transverse processes of the last cervical vertebra. Of these I have seen many instances, and have found the most various amount of motor and sensory paralysis and of trophic lesions. In some patients there is little complained of beyond slight pain, in others pain is very severe, and in others again there is paresis or paralysis of few or many of the muscles of the upper extremity. I have seen almost complete paralysis of the whole arm and forearm.

The subjects of these growths are always young, generally between eighteen and twenty-three, and in addition to exercising pressure on the nerve-trunks the exostosis may also compress the subclavian artery. In such cases the pulse in the affected limb may be much weakened, or indeed obliterated, and in my opinion all the cases of so-called "obliterating arteritis" hitherto described in this country are examples of pressure by exostoses.†

The proper treatment, when the symptoms are sufficiently severe to warrant operation, is to remove the exostosis by dissecting down to it and cutting it off with bone forceps. In all cases the operation is troublesome, and in some difficult and tedious.

The following case is a fairly typical one of the kind :

Cervical Exostosis compressing the Brachial Plexus.

F., aged twenty-three, was admitted into St. Bartholomew's Hospital on Feb. 8, 1887, under Mr. Willett. She first noticed a swelling on the right side of the neck in June 1886, but this caused her no trouble at the time. In Nov. 1886 the arm began to get weak, so that she could not use it for any length

* *Proc. Path. Soc. of Philadelphia*, 1863 : Drs. Agnew and Packard.

† *Lancet*, 1888, vol. i. p. 630.

of time. Present condition: Has a typical cervical exostosis, over which the subclavian artery can be felt raised and flattened. The pulse in the brachial and radial arteries also is so weak as to be almost imperceptible. Arm, forearm, and hand cold, livid, and blue. No œdema. Muscles of hand flabby, ball of thumb wasted, grip weak. Nails of thumb, index and middle fingers fibrous and striated. Sensation so much impaired over the median area that a prick can hardly be felt. The patient would not consent to any operation, and left the hospital in the same condition as on admission.

Compression of Nerves during Parturition.—In addition to the more common methods by which nerves may be compressed, the paralysis, generally partial, which may follow delivery, deserves mention. By some authors it is supposed to be due to the application of instruments, but this is denied by others, and with apparent justice. When any symptoms occur, the labour will generally be found to have been extremely painful, and often marked by cramps and numbness of the lower extremities. As a rule, the resulting troubles are not severe or of long duration, and the ultimate prognosis is favourable.

Pressure by Cicatrices.—In a certain number of cases, a wound which, though passing close to a nerve-trunk has not divided it, subsequently causes symptoms of interference with the nervous functions; these symptoms may usually be referred with justice to pressure exercised upon the nerve by the contraction of the scar tissue. And, indeed, it is rather surprising than otherwise that this is not more frequently the case; wounds in the proximity of nerve-trunks are by no means uncommon, while any resulting symptoms are somewhat rare. But as in the case of the spinal cord, so also in the case of nerve-trunks, a slow and gradual compression seems to be borne with ease, while a much less amount of constriction, suddenly applied, results in abolition of the nervous functions. The symptoms may supervene either during the healing of a wound, or else during the subsequent contraction of the cicatrix; they generally commence with neuralgic and shooting pains, numbness and tingling referred to the periphery, and sometimes hyperæsthesia. Later on, the muscles lose power, become subject to twitchings and jerkings, and finally are paralysed; sensation becomes impaired, and the skin gradually passes into a condition of complete anæsthesia.

The following is a fairly typical case:

W. S., aged eighteen, was admitted into St. Bartholomew's Hospital on Aug. 5, 1879, with the history that two months previously he had sustained a severe wound across the front of the wrist. This was rapidly followed by loss of sensation in the index, middle, and half the ring fingers, accompanied by pain, which did not seem to be very severe. The thumb muscles were weakened, but not entirely paralysed; there were no trophic lesions. On Aug. 9th the scar was opened up, and, contrary to expectation, the median nerve was found to be entire, but bound down and compressed by a considerable amount of cicatricial tissue. From this the nerve-trunk was disentangled, and then stretched in both directions. The patient remained under observation till the 29th of the month without undergoing any improvement, and since that date I have been unable to learn anything as to his future progress.

A consideration of this case, and of those on page 241, affords sufficient proof of the effect of compression by cicatrices. The symptoms are practically those of partial or complete section, with or without the accompaniment of the various trophic lesions already described. In making the diagnosis of such a case, it is to be noted that as a rule the symptoms do not supervene until the wound has healed or is healing, and in this respect they differ from the symptoms of section which are necessarily the immediate result of injury.

Treatment of Pressure.—The treatment of the various forms of pressure resolves itself to a great extent into the removal of the cause: thus, in crutch palsy, or pressure of a tumour, a cessation of the use of the crutch in one case, and the removal of the tumour in the other, will suffice to bring about a cure. Where the pressure has been of long duration and the paralysis is more or less complete, accessory treatment will be requisite to accelerate the cure, and to this intent galvanism, friction, shampooing, &c., should be recommended. In rare cases, the symptoms persist in spite of treatment, a condition which is probably due to the causation of a certain amount of inflammation by the pressure, and the subsequent formation of adhesions around the nerve, often combined with the thickening of the trunk itself from chronic neuritis. Here, again, I believe that the proper treatment consists in a free exposure of the nerve, a freeing of it from surrounding adhesions, and forcible traction both upwards and downwards.

The particular form of pressure most likely to require such energetic treatment is naturally enough that which results from the contraction of scar tissue after the infliction of a lacerated wound in the neighbourhood of a large trunk ; these accidents are most common about the wrist. Under such circumstances the cicatrix of the former wound should be opened up, and the nerve-trunk cleared from all the surrounding adhesions and cicatricial tissue ; some such instrument as an aneurysm needle should then be passed under the trunk, and the latter stretched with a considerable amount of force.

The benefit accruing from such a method of treatment is instanced by many cases under different surgeons, of which the following are fairly typical examples :

Professor von Nosengeil * records a case of paralysis of the extensor muscles of the arm, due to pressure on the musculo-spiral nerve by a cicatrix in the upper arm. Complete cure resulted from an operation in which the nerve was dissected free of the surrounding adhesions.

Vogt † records a case of wound of the wrist with resulting cicatrix, causing pressure on the ulnar nerve, and stiffness and neuralgia of the fourth and fifth fingers. Vogt dissected both nerve and tendons from the surrounding dense tissue, and cured the patient.

A similar case is recorded by the same author, ‡ in which similar symptoms yielded to a like operation combined with nerve stretching. It is also of importance to obtain union by first intention if possible, for it is evident that profuse suppuration is liable to lead to a recurrence of the scar pressure for which the operation has been undertaken. The following cases indicate both the symptoms of scar pressure and its proper treatment by operation :

Inflammatory pressure on Median Nerve.—Exposure.—Cure.

Mary B., aged twenty-two, was admitted into St. Bartholomew's Hospital, under Mr. Marsh, on May 22, 1887. Five weeks previously she cut her forearm over the region of the median nerve. A few days later she began to suffer pain in the forearm and hand, and this increased until her admission.

* *British Medical Journal*, Oct. 26, 1878.

† *Rev. des Sci. Méd.*, vol. ix. p. 305.

‡ *Ibid.* vol. ii. p. 285.

May 24th.—Present condition : There is no muscular wasting, and the muscles contract voluntarily. There is, however, some spasm about the movements of the hand and wrist, and the hand cannot be used on account of the pain caused thereby. There is a scar over the middle of the forearm, and pressure along the course of the median nerve below this causes pain. The fingers are doubled into the palm and cannot be voluntarily extended. The palmar surfaces of the middle and half the ring fingers as well as the dorsal surfaces of the second and third phalanges are anæsthetic. Index and thumb normal. No trophic lesions.

26th.—In spite of complete rest the pain has increased, and the hand cannot be used at all on account of the suffering caused by movement.

27th.—An incision in the middle of the forearm exposed the median nerve just beneath the scar. It was quite natural in colour and had not been wounded. The operation gave complete relief, and although the wound suppurated freely, the patient was quite restored to health on leaving the hospital.

Scar Pressure on the Median Nerve.—Operation.

May M., aged twenty, was admitted into St. Bartholomew's Hospital, under Mr. Smith, on Oct. 24, 1887. She had cut her wrist with broken glass five weeks before admission, and said that she could not straighten her fingers. She also complained of pain. Present condition : Scar above wrist in the line of the median nerve. The fingers are contracted spasmodically, and there is partial loss of sensation in the median area. No wasting. Electrical examination : Reactions to both currents normal.

Nov. 3.—Operation : The median nerve was found to be adherent to the scar, and the anterior surface was a little notched. The nerve was freed from the scar and the wound sutured. The patient improved quickly, but was not quite recovered on her discharge on Nov. 14.

Anæsthesia from Scar Pressure.—Operation.—Cure.

John T., aged thirty-four, cut his forearm in January, and on Aug. 10 was admitted with complete anæsthesia in the median area. Operation : The median nerve was found compressed by

scar tissue, which was cut through. On recovering from the anæsthesia the fingers were found to be quite normal.

Le Fort.—Paralysis of Median Nerve after Gunshot Injury.—
Nerve freed from Scar Tissue and stretched.—Recovery.*

A gentleman was accidentally shot in the arm by a fellow-sportsman. The patient was immediately seized with severe pain in the wounded limb, and the forearm became paralysed. The gun was loaded with No. 5 shot. Pain continued acute, but was greatly increased on movement. The symptoms were considered to be due to a wound of the median nerve, and the presence of a shot pellet in contact with the nerve-trunk was diagnosed. An operation did not discover any shot, and the patient was not improved. Six months after the accident he was seen by M. Le Fort. Pain was still extreme, the arm was carried in a sling and could not be used for any purpose. There was hyperæsthesia in the median area, and wasting of the muscles innervated by this nerve. The scar of the original wound was about two inches above the elbow, on the inner side of the arm. In this situation there was much induration. An incision was made at this spot, and the median nerve exposed. It was found to be closely surrounded by an indurated mass of fibrous tissue, from which it was thoroughly freed. The nerve-trunk was then stretched. After the operation, pain still continued, but was much diminished; the improvement was maintained and a complete cure resulted within three months of the operation, the induration almost entirely disappearing.

* *Bull. et Mém. et de Soc. de Chir. de Paris*, 1882, vol. viii. p. 575.

CHAPTER XIV.

VARIETIES OF NERVE INJURIES—(*continued*).

Nerve Injuries Complicating Fractures.—Paralysis of the parts supplied by any nerve may result in various ways in cases of fracture, and it is of some importance to clearly recognize the various causes to which this paralysis may be due.

First. In any case of fracture one of the neighbouring nerves may be contused at the time of injury, or may be stretched.

Second. The nerve may be compressed by the displaced bone, or by a fragment of bone in the case of a comminuted fracture.

Third. The nerve may be compressed by callus subsequent to the time of fracture.

Fourth. The nerve may be completely lacerated.

The following case by Mr. Hulke may be referred to as a good example of the first kind of injury :

M., aged thirty-six, sustained a fracture of both humeri, the left being comminuted, and the soft parts much bruised. Sensation returned very slowly, and was quite absent two months after the accident, but subsequently, after a year or more, was perfect. "The suspension of conductivity and its return are, I suggest, most easily explained by supposing that after the humerus was broken the nerves were overstretched by the strain falling on them, but not completely torn through."

The two following cases by Bidder are also excellent examples of slight contusions or stretchings of the musculo-spiral nerve complicating fracture of the humerus. In each there was paralysis immediately after fracture, and in each a rapid restoration of function ensued.

Bidder.—*Fracture of the Humerus, followed by transient Paralysis of the parts supplied by the Musculo-spiral Nerve.*

A young man, aged eighteen, fell from his horse against some railings and fractured his humerus. The same evening it was noticed that the muscles supplied by the musculo-spiral nerve were paralysed. There was also anæsthesia of the back of the thumb, and of the index finger. Eight days later there was hyperæsthesia of the previously anæsthetic parts. This gradually disappeared, and then, under treatment by electricity, motor power completely returned in four months.

*Bidder.**—*Fracture of Humerus, with transient Paralysis of parts supplied by the Musculo-spiral Nerve.*

An officer fell from his horse and sustained a fracture of the lower third of the humerus implicating the elbow-joint. There was immediate paralysis of motion and of sensation in the parts supplied by the musculo-spiral nerve. In a few days sensation returned, and then, under the influence of massage, motor power was completely restored in three months.

Compression by a displaced fragment of bone is well instanced in the following case :

Smith.—*Fracture of the Bones of the Forearm with injury to, and pressure on, the Median Nerve by a displaced portion of Bone.—Operation.—Relief.*

Henry H., aged twenty-four, was admitted into St. Bartholomew's Hospital on March 31, 1885. Ten weeks previously he had sustained a compound fracture of the forearm at the junction of its lower and middle thirds. He had scarcely used the arm since the accident. Present condition : A small sinus on the front of the forearm leads to necrosed and bare bone. Almost complete anæsthesia of the index and middle fingers on their palmar surfaces as well on the palmar surface of the thumb, and on the dorsal surfaces as of the second and third phalanges of the index and middle fingers. The muscles of the thumb supplied by the median nerve are wasted.

* *Rev. des Sci. Méd.*, Oct. 1885.

April 10th.—Operation: The necrosed bone was found at the bottom of the sinus, and the median nerve was seen to be tightly stretched over a displaced fragment of fractured bone which had acquired a fresh attachment to the radius. The nerve was thinned at the seat of pressure. The bone was cut away with forceps, and the nerve freed from all pressure.

11th.—Some return of sensation in the thumb.

15th.—Further return in the index finger.

27th.—Discharged. He can feel in the thumb, index and middle fingers, though not yet as well as in the other hand. The muscles are still wasted and paralysed. The patient went to sea and has not since been heard of.

In the following cases it is probable that the paralysis was due to pressure on the nerves by displacement of the fractured ends of the bones, and by callus:

*Fracture of the Humerus, with partial Paralysis of the
Musculo-spiral Nerve.*

Albert W., aged fifteen, met with a severe machinery accident in August 1883. The humerus was fractured. It united with the formation of much callus, and on Jan. 12 there was paralysis of the extensors and supinators of the hand and forearm with wrist-drop. The patient was treated by galvanism, and improved, the muscles gradually coming under the control of his will, although not reacting to faradism. In the course of a few weeks he completely recovered.

Willett.—Fracture of Forearm with bad union, followed by Anæsthesia and Wasting of the Muscles supplied by the Ulnar and Median Nerves.—Refracture.—Galvanism.—Cure.

James J., aged nine, was admitted into St. Bartholomew's Hospital on Oct. 26, 1885. He had met with a fracture of his forearm on June 10, and had been treated with splints. Since then the hand had become numb, and he had lost power in it. Present condition: In the middle of the right forearm is a large mass of callus. The hand is partially supinated and flexed. All the fingers are flexed. The tendons are evidently caught in the callus, and the fracture has united in bad position. There is

anæsthesia over the median distribution in the fingers and thumb. The skin is blue, the fingers cold, and the nails rough. The muscles supplied by the median and ulnar nerves are wasted. Electrical examination: No reaction at all of any of the hand muscles.

Oct. 28th.—The forearm was refractured and the fingers were forcibly extended. After refracture there was for several weeks a gradual return of sensation and of motion, and at the time the patient was discharged, on Dec. 31, the thumb could be abducted and adducted as well as opposed. There was slight power of pronation and supination, and the muscles were much improved in bulk. He could localize in the thumb and middle fingers well and accurately; in the index he localized badly, but there was nowhere absolute anæsthesia.

July 9, 1886.—The hand is now quite well as regards the nerve supply. Sensation is perfect to all stimuli. There is now but little stiffness of the hand, the middle finger being the only one affected. Its tendons are still implicated at the seat of fracture. There is but little callus, and the hand is useful and strong. There is no paralysis or wasting of any muscles, and all react well to galvanism and faradism.

Pressure by callus is more especially prone to affect nerves which lie in close contact with the bones, and of all nerves the musculo-spiral is the most frequently paralysed. This paralysis is, however, of comparatively rare occurrence when the fractured ends are in close apposition, but is prone to occur when much displacement (and often a proportionate amount of callus) results from the injury.

The symptoms are precisely similar to those already detailed as following on compression from other causes, and a repetition is consequently unnecessary.

As in cases of scar pressure, the symptoms may supervene either shortly after the fracture or else at a later date. In the former case an unfavourable prognosis should not be too readily given, for, as the provisional callus is absorbed, the pressure on the nerve may subside.

One of the best known cases of this kind is that recorded by Paget, on the authority of Mr. Hilton, in which a fracture of the lower end of the radius was followed by compression of the median nerve, and consequent ulceration of the thumb, middle

and index fingers. When the wrist was kept flexed so as to relieve the pressure on the nerve, the ulcers healed, but broke out again when the hand was allowed to resume its former position.

The following case is, as far as can be ascertained, one in which the nerves were completely torn at the time of the accident, for although the patient was seen as late as a year and a half after the injury, there was no attempt at repair :

Willett.—Compound Fracture of the Humerus, with injury to the Median and Ulnar Nerves.

E. D., aged thirty-three, came into St. Bartholomew's Hospital on June 18, 1884. A year previously, in a storm at sea, he sustained a compound fracture of the left humerus and the left leg. The latter was amputated. There was suppuration and erysipelas of the arm, and incisions were freely made. Since then the arm has been paralysed. Present condition: Complete paralysis of all the muscles of the forearm supplied by the median and ulnar nerves. No sensation in the fingers, thumb, or palm of the hand. The nails are ridged and furrowed. The skin is blue and cold, and the hand is perfectly useless. The finger-joints are stiff and the fingers doubled up. On several occasions the parts were freely manipulated under chloroform, but with no material benefit to the patient.

In Dec. 1884 there was no further improvement.

I have now given instances of the various ways in which nerves may be injured in cases of fracture, and shall proceed to point out the different individual fractures in which such injuries have been noticed. Before doing so, however, I shall venture to allude very briefly to two cases of an exceptional character in which portions of fractured bones have been found actually grafted on to the nerve-trunks into whose neighbourhood they had been displaced.

The first case is recorded by Tillaux,* on the authority of Verneuil. The bones of the elbow were fractured by a gunshot wound, and, resection having failed, the arm was amputated at the end of one month. A small piece of newly formed bone was then found imbedded in the musculo-spiral nerve, and it was

* *Loc. cit.*

supposed that it owed its origin to the accidental transplantation of a fragment of periosteum to this position.

The other case is reported by Dr. Weir Mitchell.* The patient had sustained a fracture of the humerus from a gunshot wound, and the post-mortem discovered a small portion of bone attached to, and growing on, the sheath of the median nerve.

Fractures of the Bones of the Face.—In fractures of either the upper or lower jaw, the second and third divisions of the fifth may respectively be wounded. As the former are rare, the following case may prove of interest:

A young man applied at St. Bartholomew's Hospital, a week after receiving a severe blow on the face, which he had sustained while playing football, and which he thought had been caused by an opponent's boot. When the swelling subsided, he found that sensation was lost over the left cheek, and for this reason he applied to the hospital. On examination I found that the superior maxillary bone was fractured, the line of fracture passing vertically downwards in a direct line with the orifice of the infra-orbital canal. The left cheek, lower eyelid, and part of the side of the nose were devoid of sensation, and a pin prick elicited no feeling of pain. During the few weeks he remained under notice there was no improvement.

In the lower jaw it is by no means unusual to find that a fracture has implicated the inferior dental nerve in some part of its bony canal. I have myself seen cases in which the portion of skin supplied by this nerve was anæsthetic, as was also, to a certain extent, the gum on the corresponding side. Many similar cases have been noted by other authors, and indeed, considering the position of the nerve, we may well be surprised that it escapes as frequently as it does.

Fractures of the Clavicle.—The only two cases of fracture of the clavicle complicated by injuries to nerves which I have found recorded are those by Mr. Earle and Dr. Weir Mitchell. In the first, which may be found in vol. vii. of *The Medico-Chirurgical Transactions*, the clavicle was comminuted and the arm paralysed; the patient completely recovered. The second is briefly alluded to by Mitchell in his work already quoted.

Mr. Barker† has recorded an interesting case which has some

* *Trans. of the College of Physicians of Philadelphia*, vol. ii. 1876.

† *Transactions of the Clinical Society*, vol. xix. p. 104.

bearing on this subject. His patient was a lad, aged twelve, who had suffered from an ununited fracture of the clavicle since birth, and for three years had complained of pain in the arm of the affected side. For two months there had also been writer's cramp and increased pain in the forearm. There was slight muscular wasting and tenderness of the cords of the brachial plexus. The ends of the fractured clavicle were exposed, and sutured with wire, the operation being quite successful in promoting union of the bone, and in restoring the normal functions of the nerves and muscles.

Fractures of the Scapula.—Swan records a case* of fracture of the glenoid cavity, followed by neuralgia and paralysis of the arm. The patient was a lady, aged sixty, and at the end of fourteen months had recovered nearly perfect use of the upper extremity. It is, of course, evident that the nerves of the arm are but little likely to be implicated in fractures of this bone.

Fractures of the Humerus.—Fracture of the shaft of the humerus is more frequently the cause of nerve-lesion than similar accidents in any other part of the body. The nerve most commonly implicated is the musculo-spiral, where it lies in the groove in the bone.

The following case, recorded by Mr. Erichsen, is fairly typical: †

“E. L., aged twenty-nine, by occupation an ironer; admitted Dec. 16, 1871. Ten weeks since, the patient fell and fractured her humerus about the middle. She was treated as an out-patient, and the limb was put upon an angular splint, so as to fix the elbow-joint. When the splint was left off at the end of four weeks she was directed not to use her arm for a week. She noticed wrist-drop when she left off the splint, but thought it was mere weakness. At the end of a week, however, on trying to use her hand she found that she had no power in the wrist or fingers. It was thought to be weakness, and she bathed it with cold water. The hand has for some time felt colder than the other. On examination it is found that there is marked wrist-drop, with pronation. She cannot extend the hand at all. The right forearm, fingers and hand are swollen. She feels a difference in the temperature of the two hands, but not so great as formerly. Occasionally she has a feeling of pins and needles all down the hand and fingers. The thumb and index finger are

* *Diseases and Injuries of Nerves*, p. 162.

† *Lancet*, July 1871.

numb on the dorsal aspect, especially the former. Sensation is imperfect. Flexion of the fingers is imperfect owing to stiffness of the knuckles. The temperature of the injured hand does not raise the index of a clinical thermometer to 85° : that of the other is 96° . All the muscles supplied by the musculo-spiral nerve are paralysed completely. She has consequently lost all power of extending the wrist. She has no power of extending the thumb. She has no power of extending the fingers from the metacarpo-phalangeal joints; but when the fingers are completely flexed, she can extend the joints between the first and second and the second and third phalanges. This is evidently accomplished by means of the interossei and lumbricales, which are attached to the expansion of the extensor tendons on the dorsum of the fingers lower down than the metacarpo-phalangeal joints. On holding the index finger forcibly down and telling her to try to extend it, the thumb is drawn in towards the palm, "by the attachment of the first dorsal interosseous to the metacarpal bone of the thumb. Supination can be performed apparently in a very feeble and imperfect manner, but only when the forearm is fixed. Flexion of wrist, hand and fingers is perfect."

A most interesting case of callus pressure has also been recorded by Ollier:

"A man, aged twenty-two years, sustained a fracture of the humerus at the junction of the lower and middle thirds. It was kept in a starch bandage for forty days, and caused intense pain. At the end of this time the extensors were found to be paralysed, and as this condition continued four months later, M. Ollier cut down upon the musculo-spiral nerve, at the seat of fracture. The nerve was found swollen like a ganglion, and strangled by the pressure of a piece of bone obliquely placed across it, which was connected with the lower fragment. At this point the nerve was compressed as if by a ligature, and measured three millimetres in diameter, while, above, the swollen trunk attained the breadth of one centimetre, and below this point was but slightly enlarged." The portion of bone causing the symptoms was removed, and the patient almost entirely recovered.

The following cases by various surgeons further illustrate both the nature and treatment of certain cases of musculo-spiral paralysis in connection with fracture of the humerus:

Trelat.—Fracture of Humerus with Paralysis of the Musculo-spiral Nerve.*

In 1874, in a young boy who had broken his humerus, this surgeon found a considerable amount of exuberant callus and paralysis of the extensor muscles of the hand and fingers. An operation was performed, and the musculo-spiral nerve was found stretched over a portion of bone, and flattened. The bone was removed, and the patient in a few months regained the complete use of his arm.

Whitson.†—Paralysis of parts supplied by Musculo-spiral Nerve following Fracture of Humerus.—Removal of Projecting Fragment of Bone.—Improvement.

The patient was a working-man, who had sustained a fracture of the humerus in July 1881. The fracture was put up in splints, and united, but the extensor and supinator muscles were paralysed. "On examining the upper arm, a spiculum of bone was found about three inches above the elbow, which projected in an oblique direction. . . . On Nov. 23, 1881, an operation was performed, and the musculo-spiral nerve was exposed at the seat of fracture. The nerve was found to be partially enclosed in an osseous groove formed in the displaced fragment, and so much pressure had been exercised upon it that it was distinctly thinned at that point. The nerve was then removed from the osseous bed in which it was partly imprisoned, and being held aside, the projecting fragment was removed with a chisel. The irregularities in the humerus were then pared down."

Two days after the operation the patient said he could move the thumb and fingers more freely. Within five weeks the grasp of the hand had considerably strengthened, and the mobility of the fingers had greatly increased. No further particulars are given.

Dérens.‡—Paralysis of Musculo-spiral following Fracture of Humerus. Operation.—Nerve freed from Callus.—Improvement.

On Sept. 27, 1879, a man, aged thirty-seven, sustained a fracture of the lower third of the humerus, which was treated with splints for six weeks. At the end of that time, when the splints

* *Gazette des Hôpitaux*, 1882, p. 1010.

† *Edinburgh Medical Journal*, 1881-2, vol. xxvii. p. 724.

‡ *Bull. et Mém. de la Soc. de Chir.*, vol. vi. p. 262.

were removed, it was found that the usual signs of paralysis of the musculo-spiral nerve were present; there was complete wrist-drop, and impairment of sensibility. The application of electricity caused no muscular contraction, and was continued for a fortnight without good result. The callus was not excessive, but it was nevertheless considered probable that the musculo-spiral nerve was thereby compressed.

On Nov. 24th an incision was made down to the seat of fracture. The musculo-spiral nerve was found to be embedded in callus for a length of eighteen millimetres, being so firmly fixed that no traction produced the slightest result. The nerve was partly surrounded by fibrous tissue, partly by bone, and was freed by cutting away some of the osseous tissue that surrounded it. On being exposed, the nerve was found to be flattened; numerous spicules of bone were adherent to it.

By Nov. 26 the patient was able to raise the hand so as to be in a straight line with the forearm, but the further progress of the case appeared to be delayed by a phlegmonous inflammation of the other arm.

In March 1880 there was still considerable loss of power.

Israel.—Paralysis of parts supplied by the Musculo-spiral Nerve resulting from a Fracture of the Humerus.—Nerve freed from Callus by Operation.—Recovery.*

A young man sustained a comminuted fracture of the humerus, which was followed by paralysis of the muscles supplied by the musculo-spiral. After the fracture had united the nerve was exposed and found to be flattened and adherent to the periosteum of the upper fragment. From this it was freed, and some of the callus was cut away. The wound healed well, and in three months the paralysed muscles had entirely recovered.

Tillaux.†—Paralysis of Musculo-spiral Nerve after Fracture of Humerus.—Operation.—Callus cut away.—Recovery.

A man, aged fifty-three, broke his right humerus on Nov. 13, 1877. By Jan. 1, 1878, the fracture had united, but there was

* *Gaz. Heb. de Méd.*, 1884, p. 281.

† *Bull. et Mém. de la Soc. de Chir. de Paris*, 1862, vol. viii. p. 836.

complete paralysis of the musculo-spiral nerve. On Jan. 16 the nerve was exposed at the seat of fracture, and was found to be enclosed in a bony canal, covered in by fibrous tissue for a length of three centimetres. From this canal the nerve was freed, and was found to be flattened and inflamed. The wound healed well and improvement was rapid. Movements of extension of the fingers could be performed by Jan. 25, and by Feb. 27 recovery was complete.

Trélat.—Pressure on Musculo-spiral by Callus, after Fracture of Humerus.—Operation.—Cure.*

On March 19, 1882, a man, aged forty, sustained a comminuted fracture of the right humerus. This was treated with plaster splints. A month later there was found to be much callus, flexion of the elbow was imperfect, and all the muscles supplied by the musculo-spiral nerve were paralysed. There was complete wrist-drop, but no loss of sensation. The paralysed muscles did not react to electrical stimuli. Treatment by douches and galvanism produced no good results, and on June 1st the bone was exposed at the seat of fracture. The musculo-spiral nerve was found enclosed in a deep gutter of bone, roofed in by fibrous tissue for a length of five centimetres. From this it was freed by cutting away the exuberant callus. Scarcely any improvement was apparent till the end of August, and then power began to return in the paralysed muscles. By the end of December the cure was complete.

In addition to the musculo-spiral nerve, either the median or ulnar nerves may be damaged in cases of fracture of the humerus, especially in such as occur at the lower end of the bone.

The following is a case in point:

Lange.—Fracture of the Humerus with injury of Median Nerve. Operation.

A girl, eight years old, fractured the left humerus above the condyles, in August 1882. Three weeks later there was painful contraction of the fingers and wrist. From the time of the injury she had pain at the seat of fracture. In December she came to New York, and at that time the wrist and fingers were flexed to

* *Bull. et Mém. de la Soc. de Chir. de Paris*, 1882, vol. viii. p. 834.

their utmost, and the movements of the fingers were very slight. Every attempt to stretch the parts was followed by intense pain, especially at the seat of fracture, where there could be distinctly felt a sharp protruding edge of bone, and between the fragments there seemed to be a sensitive cord which it was thought might be the median nerve. There was paralysis of sensibility in the region of the median and radial nerves, and entire absence of electric irritability. For six weeks electricity and massage, with active and passive movements, were tried, but without success. On Jan. 20 an operation was performed, the median nerve was exposed at the seat of fracture, and was found to be flattened by a sharp edge of bone. Above this point it was swollen and thickened. The swelling which was felt before the operation was a mass of muscular fibre belonging to the brachialis anticus. The nerve was freed, and the protruding portion of bone removed. After the operation there was decided improvement, but at the time that the case was reported the strength of the muscles supplied by the median nerve had not improved very much. The colour and temperature of the skin were improved, and the latter eventually became normal.*

In the next case a fracture of the lower end of the humerus with formation of callus resulted in a transient paralysis of the *ulnar nerve* many years after the original accident:

Panas.—Paralysis of the Ulnar Nerve coming on twelve and a half years after a Fracture in the Region of the Elbow.

The patient was a man, aged forty, who applied to the Hospital, in Nov. 1875, for weakness of the arm, which prevented him from following his occupation of a shoemaker. This weakness he had noticed for six months. An examination of the affected hand showed the characteristic wasting and deformity which accompanies a lesion of the ulnar nerve. The muscles on the inner side of the forearm were also wasted. Sensation was diminished and the patient complained of tingling and numbing pains. The paralysed muscles responded only feebly to electrical currents. On further questioning the patient he said that twelve and a half years previously he had sustained an injury—probably

* Meeting of the New York Surgical Society, Feb. 27, 1883.

a fracture—to the left elbow-joint, and that since that time he had never been able to completely extend the forearm. An examination of the elbow itself revealed the presence of a considerable amount of callus, which filled up the groove which ordinarily exists behind the internal condyle. The ulnar nerve was stretched over this callus and presented a fusiform enlargement. Under treatment by galvanism the patient rapidly improved, and finally completely recovered.*

In Nov. 1888, I saw a very similar case. A gentleman, aged thirty-nine, had for ten months noticed wasting of the muscles of the hand. He said that his elbow had been injured in infancy, and that he had never been able to fully extend the forearm. Ten years before I saw him he had noticed occasional twitching of the muscles of the ball of the little finger, and for some years had had sensations of pins and needles in the parts supplied by the ulnar nerve, and aching pain in the elbow. I found that there was some thickening about the elbow-joint, and that the ulnar nerve for about two inches of its length in this situation was about four times its normal thickness, and very tender. There was no loss of sensation, but the muscles supplied by the ulnar nerve were much wasted, although they reacted to faradism and galvanism.

Fractures of the Bones of the Forearm.—Instances of nerve injury in cases of fracture of the bones of the forearm are certainly rare. A few pages back I have recorded one such case, due to pressure on the median nerve by the displaced bones. Mr. Callender* has also recorded an instance in which fracture of the radius at its carpal end was followed by great pain along the course of the musculo-cutaneous nerve, accompanying the lower third of the radial artery in the forearm, and was rendered much worse by the patient's attempts to use the hand. Excision of a portion of nerve above the fracture resulted in a cure.

The same author refers to another case of fracture of the lower end of the ulna; the ulnar nerve was found caught between the broken fragments and firmly wedged in its new position. The following somewhat analogous case is related by Mr. Chauncy Puzey:—

* *Archives Générales de Médecine*, 1878, vol. ii. p. 12.

† *St. Bartholomew's Hospital Reports*, vol. v.

Chauncy Puzey.—*Progressive Paralysis of the Ulnar Nerve following Compound Fracture of the Bones of the Forearm.*—*Operation.*
—*Relief.*

W. P., aged fifteen, a miller's assistant, was admitted into the Northern Hospital, Liverpool, on Oct. 8, 1883. His right arm had been caught between a broad leather travelling band and a wheel, over which it passed, so that he was dragged off his feet and suspended by his arm, the result being a compound fracture of the bones of the forearm. There was a small transverse wound on the outer side of the forearm, through which about an inch of the upper fragment of the radius protruded. The fracture of the ulna was not absolutely compound, but the sharp end of the upper fragment was sticking in the skin so as to deface it. The union was somewhat delayed, but was ultimately complete. A month after the accident it was noticed that there was a tendency to obstinate flexion of the fingers, more particularly of the little and ring fingers. The flexion did not yield to mechanical treatment, and it was then ascertained that the lad had experienced curious sensations, partly of pain, partly of numbness, ever since the accident. The ring and little fingers were deficient in sensibility. It was believed that the ulnar nerve had been pinched or bruised by the sharp edge of bone at the time of the accident, and it was hoped that the effects would pass off. This was not the case, but on the other hand the numbness gradually increased and the fingers wasted at the tips. Circulation was sluggish, hand cold, skin moist and clammy. Then the interossei and lumbricales wasted, and the adductor pollicis and the muscles of the little finger followed suit. Combined with the numbness there was evidently a considerable amount of pain on any attempt being made to straighten the flexed fingers, and a dragging sensation was complained of at the seat of the fracture. The hand assumed the clawed appearance typical of ulnar paralysis.

On April 28, 1884, an exploratory operation was undertaken. An incision was made as for exposing the ulnar artery, the centre of the incision being over the thickened bone at the seat of fracture. The latter was satisfactorily united, the upper fragments projecting very slightly above the lower. There was some thickening from callus, and, moreover, what seemed to be a band of thickened periosteum stretched over the callus. The wound was enlarged upwards and the nerve was then found unmistakably

and was traced into this band. Then the incision was extended downwards towards the wrist, and what was thought to be nerve was found and proved to be continuous with the band; but whereas the nerve above the adhesion was pink and fleshy-looking, the part below was colourless and wasted. Partly by the knife and partly by gentle elevation the nerve was freed from the bone, so that it could be lifted above the level of the wound and thoroughly examined. The upper part was evidently swollen, the part which had been fixed down was thinned and flattened, the lower end was round, but pale and apparently wasted. To prevent the lately adherent portion from dropping down into its old situation and probably again becoming attached to the bone, a few fibres of the flexor carpi ulnaris with the adjacent flexor profundus digitorum were connected by a catgut suture, and a fleshy bed was then interposed between the bone, and three days later the patient was able to tell when the skin of the proximal phalanges of the little and ring fingers was pinched, and appeared to have perfect sensation along the adjacent sides of the little and ring fingers. On May 7th there was increasing sensibility of the fingers extending towards the tips. The patient made the remark that for the last two or three days he had felt a sensation as of blood rushing along towards the finger-ends. On May 20th, the wound was healed and tactile sensibility was rapidly increasing. Eight months later there was hardly any appreciable difference in sensibility between the two hands. The muscles had been restored to their natural bulk, and the colour of the skin and nails was normal. The lad had returned to his work. Mr. Puzey was of opinion that in this case the ulnar nerve had been caught by one of the fragments at the time of fracture and dragged down, becoming subsequently compressed by the callus.*

The only other nerves likely to be injured in fractures of the radius and ulna are the interosseous trunks. I have not, however, met with any record of such cases.

Fractures of the Lower Extremity.—In fractures of the various pelvic bones, injuries to nerves are not frequently met with; I have, however, seen two such cases. In both of these the pudic nerve was the trunk involved, and the bone fractured the pubes. In each the accident was severe, and subsequently proved fatal to the patients, one a child and the other a man. The fractures were both compound, and the perineum much lacerated.

* *British Medical Journal*, 1885, vol. i. p. 979.

Fractures of the Femur, implicating any of the nerves in the thigh, are likewise rare; one instance is recorded by Swan, in which the sciatic nerve was lacerated in an old man, who sustained a severe fracture of the neck of the femur, which proved fatal in about two months; but, with this exception, I have seen no accounts of such an accident.

In the following case a fracture of the femur, with formation of much callus, was followed by paralysis of the parts supplied by the peroneal nerve. The nerve, having been freed from callus, was stretched, and a good result ensued:

Szuman.—Stretching of the External Popliteal Nerve, on account of Paralysis following Fracture of the Femur.*

A man, aged thirty-one, fractured his right femur in its lower part on Dec. 18, 1881. In consequence of his constantly moving the limb the fracture joined in a bad position, and the knee was flexed. There was a good deal of callus, and the patient could scarcely walk. On May 2, 1882, osteotomy of the femur at the seat of fracture was performed in order to improve the position. Six weeks after the operation it was found that the muscles innervated by the peroneal nerve were paralysed, and that the limb and foot were partially anæsthetic. On June 21st an incision was made in the popliteal space. The peroneal nerve was found completely surrounded by callus. From this it was freed and was stretched. Four days later the patient commenced to move his limbs, and on July 22nd there seemed to be no adhesion of the nerves, but there was still paralysis of the muscles supplied by the popliteal. In April 1883, the patient was again seen, and it was found that the paralysis had almost completely disappeared, the only remnant of it left being paralysis of the great toe.

In connection with this subject I may also mention that in two cases of Macewen's osteotomy of the femur for genu valgum, I have seen paralysis of the parts supplied by the peroneal nerve. In one patient the paralysis persisted for several months, and in the other it lasted for three months, during most of which time

* *Rev. des Sci. Méd.*, 1881, p. 304; *Deut. Med. Woch.*, No. 52, 1883.

the reaction of degeneration was well marked. Both patients made complete recoveries.

In Fractures of the Bones of the Leg the nerve-trunks are more frequently injured, the anterior and posterior tibials, or the peroneal, may all be implicated. The following is a good case of injury to the peroneal :

“C. C., aged eighteen, was admitted into Harley Ward, St. Bartholomew's Hospital, on July 27, 1882, suffering from a compound fracture of the fibula at about its middle. The parts supplied by the nerve were anæsthetic, and the muscles paralysed. The wound healed slowly, but on Nov. 11th an herpetic eruption appeared low down on the outer side of the leg, and remained for several days before it commenced to die away. On the 19th of the same month the leg was galvanized, and this treatment was continued at intervals until the following March, when the foot was in a position of ‘talipes varus,’ the leg was wasted, and sensation absent. By May 29th sensation had improved, but motion was still absent.”

This case affords a good instance of trophic disturbances of a comparatively slight degree set up by fracture.

Mr. Callender* has detailed two similar cases in which fractures of the tibia and fibula were followed not only by herpetic eruptions, but also by glossy skin, burning pain, and ulceration in the course of the anterior tibial nerve.

In a similar case in which the peroneal nerve was lacerated by the broken fragments of a fractured fibula, the pain was so intense that Sir W. Lawrence amputated the limb.

Another patient suffered so severely from the burning pain, following on injury of the peroneal nerve from fracture of the fibula, that fourteen months later the leg was removed at his own request.

A similar instance is recorded by Smith,† in which a double fracture of the tibia and fibula, with tearing of the anterior tibial nerve, caused such pain that amputation was subsequently necessary.

The following cases by French surgeons illustrate the liability

* *Loc. cit.*

† *Dublin Journal of Medical Science.*

of the peroneal nerve to injury in cases of fracture of the fibula :

Duplay.—Paralysis of the Peroneal Nerve, following Fracture of the Fibula in its Upper Third.*

In two cases of fracture of the upper third of the fibula—one in a patient aged forty-six, the other in a man of sixty—it was noticed some days after the accident that there was paralysis of the peronei and of the front of the leg, and that the paralysed muscles did not respond to electricity. At the same time there was anæsthesia of the dorsum of the foot and of the first and second toes.

In the discussion which followed the reading of M. Duplay's paper, M. Terrier remarked that he had recently treated a similar injury in a young man of twenty-five of very nervous temperament. There was a similar anæsthetic area as in the case just described, together with paralysis of the peronei. Eight days after the accident symptoms of inflammation of the peroneal nerve commenced, the patient complaining of burning pain of a paroxysmal or neuralgic nature in the anæsthetic area. At the same time there was much œdema of the back of the foot. Despite treatment by cold and morphia injections the pain continued to be most acute for a month, and then only subsided very gradually.

M. Verneuil had seen a similar case of paralysis of the musculo-cutaneous nerve following fracture of the upper third of the tibia and fibula. The loss of power in the extensor muscles had not been entirely recovered from when the patient left M. Verneuil some months after the injury.

M. Berger had seen a similar case with paralysis of both the anterior tibial and musculo-cutaneous nerves.

Symptoms and Diagnosis of Injuries of Nerves complicating Fractures.—I have considered it advisable to detail the foregoing cases before entering into the question of symptoms and diagnosis, for a careful reading of the clinical details leaves but little to be said on this subject.

In cases of the first variety—namely, in which the nerve has simply been contused—the symptoms will supervene immediately

* *Bull. et Mém. de la Soc. de Chir.*, vol. vi. 1880, p. 218.

after the accident. In many cases, however, these symptoms are overlooked in face of the more apparent injury—*i.e.*, the fracture. This is especially liable to be the case when it is a motor nerve that is injured, for the loss of power due to the paralysis is masked by that which is due to the fracture. The symptoms are those which I have already detailed in dealing with the subject of Contusion of Nerves, and the prognosis may be made on the grounds already given. *Contusion*

The symptoms of complete laceration, or of compression by a displaced fragment, will also supervene directly after the injury, and it is not always possible to separate such cases from those of simple severe contusion. *Contusion*

The cases in which the paralysis is due to callus pressure do not, on the other hand, present any immediate evidence of nerve injury at the time of, or even for some days after, the fracture. Then the symptoms have a gradual onset. *Callus*

The prognosis of recovery in a case of callus pressure cannot be very exact. There is, however, no reason to doubt that, as the provisional callus is absorbed, so the symptoms caused by its presence may subside.

The treatment of nerve injury in cases of fracture is sufficiently clear.

In no case is it justifiable to operate at the time of injury in order to examine or to treat the injured nerve. Frequently no treatment is necessary, and if it is it may safely be postponed until the fracture has united. *Union*

When it is supposed that the nerve has only suffered contusion, the case may be treated on general principles, such as I have detailed at length in other pages; and if the diagnosis is correct, considerable improvement or complete restoration of function will result.

When a definitely displaced fragment of bone can be felt in the course of the affected nerve operation should not be long delayed, and in those cases of pressure by callus, in which a sufficient time has been allowed to elapse for its removal, without there being any improvement, then also operative procedures should be undertaken.

It will be noticed, on reference to the cases already quoted, that the nerve may be found simply pushed out of its course, may be completely surrounded by callus, or, lastly, may lie in a bony gutter roofed in by fibrous tissue. In any case the offend-

ing bone should be removed, all pressure should be avoided, and the nerve should be thoroughly stretched.

If the nerve has been completely divided, then its ends should be resected and sutured as described in another chapter.

In those cases in which the paralysis appears to be dependent upon union in a faulty position, the bones should be again fractured and retained in their proper place by the necessary splints. The case already recorded on page 245 is sufficient proof that such treatment may give the best results.

CHAPTER XV.

INJURIES OF NERVES COMPLICATING DISLOCATIONS.

INJURIES to nerves may be caused either by the dislocation itself, or else by the attempts made to reduce the same. The dislocations which are most commonly followed by symptoms of nerve lesion are those of the shoulder, elbow, and hip. The amount of injury inflicted on the nerves varies from a slight bruising to complete rupture and laceration of the surrounding trunks.

In the case of the shoulder, one or all the nerves forming the brachial plexus may be damaged, more especially in the sub-clavicular variety, but also to a certain extent in both the sub-coracoid and sub-glenoid; in the dislocation on to the dorsum the nerve-trunks are out of the way of the displaced bone. In the first of these varieties, the axillary nerves are compressed between the head of the bone on one side, and the clavicle and ribs on the other, and the force with which the head of the bone is driven out determines the severity of the resulting contusion. The nerve that suffers most frequently is the circumflex, which is liable to be stretched around the neck of the displaced bone, a condition which is extremely well exemplified by a specimen in the museum of St. Bartholomew's Hospital, No. 1025. In this case, the patient lived for eighteen months after a dislocation of the humerus under the clavicle, but a permanent paralysis of the deltoid with much wasting followed, and on a post-mortem examination the nerve was found stretched around the neck of the humerus; the muscular atrophy was no doubt due to interference with the proper nerve supply. Some months since I saw a similar case. The patient was a very stout man, in whom a sub-glenoid dislocation had been overlooked nearly four months before he came under my notice. The deltoid was extremely atrophied, and he complained of a good deal of pain in the shoulder. Reduction was found impracticable. Similar cases have been reported by various authors.

The symptoms of nerve-injury in cases of dislocation of the shoulder

will of course depend on the amount of injury inflicted, and also on the length of time during which the unreduced head rests on the nerve-trunks. The following are cases in point :

CASE I.—*Dislocation of Shoulder with Injury to Ulnar and other Nerves.*

Christopher P., aged thirty-seven, was admitted into St. Bartholomew's Hospital, under Mr. Willett, on Dec. 28, 1885. A year ago his left shoulder had been dislocated in a fall, and was reduced after twelve hours. For three months after the accident he could not move the left arm and hand at all, and suffered from severe pains in the paralysed parts, with sensations of pins and needles. After this time he had slight return of power and was treated by blisters and acupuncture, and in September by galvanism. He is still improving. Present condition : Shoulder natural. Muscles of upper arm atrophied. Circumference : left, nine and a quarter inches ; right, ten and a half. Elbow-joint freely movable ; muscles of forearm wasted, especially on ulnar side. Wrist-joint a little stiff, left hand much thinner than the right. All muscles supplied by the ulnar nerve are wasted and paralysed. Good power over the median thumb muscles. Sensation : Normal in forearm ; much impaired in the hand, which, he says, feels as if covered by a thick glove. He has great difficulty in detecting two points of a compass as such in any part of the hand or fingers, even when widely separated. The little finger is the worst. He can localize everywhere except on little finger. Electrical examination : Impairment of faradic and galvanic contractility in all the muscles of the left upper extremity ($\kappa.C.C. > A.C.C.$). The ulnar muscles have suffered most, and barely contract at all. Dynamometer : Right, 80 lb., left, 15 lb. Under daily galvanism the muscles improved and increased in size and strength, sensation returned, and on Feb. 12th he was practically well.

CASE II.—*Paralysis after Dislocation of Shoulder.*

W. T., aged fifty-six, was admitted into St. Bartholomew's Hospital, under the care of Mr. Marrant Baker, on June 18, 1886. He had dislocated his right shoulder five months previously. It was reduced the next day by the heel in axilla. After reduction, and directly following it, there ensued a feeling of deadness and loss of power in the arm and forearm, which has continued to the present. Condition on admission : Wasting of muscles

on dorsum of scapula, of the biceps, deltoid, and triceps, and of the extensors and flexors of the forearm. The whole arm and forearm and hand are almost paralysed, the biceps and triceps showing faint contraction, but all the muscles of the forearm are quite powerless. Electrical examination: Entire absence of faradic contractility in deltoid, biceps, triceps, and extensors and flexors of the forearm. Galvanic irritability very difficult to obtain at all. No contraction of deltoid. The extensors of arm and forearm react normally but very weakly to galvanism: K.C.C. > A.C.C. Flexor muscles show that A.C.C. > K.C.C. No contraction at all of the muscles of hand. Sensation: Normal in arm (upper), lost on the extensor surface of the forearm and in the hand and fingers, except on the flexor surface of the thumb, and of the first and second fingers. Shoulder-joint stiff. Hand and forearm cold and blue. He was treated by galvanism daily, but without improvement, until Aug. 3rd.

On Feb. 5, 1887, he writes:—"My arm is a great deal stronger, and I can move all my fingers, but my hand and wrist are still weak. Strength seems to come slowly, and I can do a little work."

On Oct. 6, 1888, he writes:—"My arm is much stronger, but my fingers are very weak and cold at times. I am still able to do my work."

CASE III.—*Old Sub-glenoid Dislocation of Shoulder.—Paralysis of Arm.—Adhesions broken down with benefit to symptoms.*

Ann B., aged sixty-four, was admitted into St. Bartholomew's Hospital on Nov. 6, 1882. Ten weeks previously her shoulder had been dislocated—the dislocation had not been reduced. An examination showed a typical sub-glenoid dislocation. The elbow was semiflexed. The wrist was hyper-extended. She could not flex any of the fingers, but could flex the arm. The thumb was almost powerless. Sensation was much impaired over the distribution of the ulnar nerve, and slightly also over the back of all the fingers. There was nowhere complete anæsthesia. Any movement of the wrist or ring finger caused much pain. Electrical examination: No reaction of the flexors of the finger and wrist or of the hypothenar muscles to faradism. The pronator radii teres acts well. The extensors and the biceps and triceps are normal. Under an anæsthetic the arm was vigorously moved, and many adhesions were broken down. The dislocation, however, could not be reduced.

On April 21, 1883, the patient reported herself much better, and only complained that the little finger felt heavy and prickly.

CASE IV.—*Morton.*—Neuritis following Dislocation of the Shoulder.—Affection of the other Arm.*

A man, aged sixty-five, fell and dislocated his right shoulder. The dislocation was at once reduced. Some time afterwards (length of time uncertain) the following condition of things was found: Pain and swelling of the right hand and wrist. The skin glazed, mottled, cold, and œdematous; nails, club-shaped; joints, painful; impairment of motion. Afterwards there was a transfer of these symptoms to the opposite member. The treatment consisted in the application of electricity over the brachial plexus, and in hot and cold douches.

CASE V.—*Pozzi.†—Traumatic Neuritis of the Brachial Plexus, following Dislocation of the Shoulder.—Secondary Affection of the other Arm.*

In this case the patient had fallen upon the elbow, and had immediately noticed severe pain in the little finger. At the same time he had suffered a dislocation of the shoulder of the sub-glenoid variety. Reduction of the dislocation was effected without difficulty, but the patient complained of severe pains radiating throughout the whole of the arm. These pains continued, and were worse at night. There was no anæsthesia or hyperæsthesia, but there was progressive weakness of the whole limb, which affected equally all the muscles. There was no deformity of the hand. All the muscles reacted slightly to the galvanic current except the interossei and the adductor of the thumb; there were also some trophic troubles. The nails became curved, and the skin assumed a bluish colour. There was abundant desquamation resulting from the rupture of small vesicles. A similar condition was found upon the other hand, and was also limited to the area of distribution of the ulnar nerve. Under treatment by electricity the patient considerably improved, but at the time that the case was reported the muscles had not entirely recovered.

It will be seen from a consideration of the above cases that

* *New York Medical Journal*, June 23, 1883.

† *Journal de Médecine et de Chirurgie Pratiques*, p. 60.

the injury to the nerve-trunks may occasionally result in inflammatory changes, and it should be remembered that in consequence the duration of the symptoms is much prolonged.

The transfer of symptoms to the other arm is a point of much interest, and is one to which I shall again refer when speaking of the subject of reflex paralysis.

The loss of motion is generally greater than that of sensation, and is sometimes present without the latter being seemingly affected. Neuralgic pains, burning, various trophic lesions, or complete anæsthesia may result, chronic neuritis may be set up, or all motion or sensation may be absent.

In the reduction also of dislocation of the shoulder, the axillary nerves may be stretched or torn; this is generally the result of adhesions which have been formed and have bound the nerves firmly to the surrounding tissues: this accident seldom follows the reduction of recent dislocations.

In dislocations of the **elbow** the ulnar nerve is occasionally torn, and more frequently bruised.

In a case recorded by Mr. Callender,* the median also was severely stretched in a compound dislocation of this joint.

Dislocations of the **hip-joint** are sometimes complicated by bruising or stretching of the sciatic nerve, caused either at the time of dislocation or else in attempts at reduction. The symptoms merit no special comment.

In dislocations about the **knee-joint** the nerves are but seldom implicated. In Guy's Hospital museum, however, there is a specimen which is described in the catalogue as "The Head of a Fibula, with a portion of the Peroneal Nerve, which was lacerated in a case of compound dislocation of that bone." Such an injury as dislocation of this bone is itself uncommon, and the nerve complication must be proportionately rare.

As far as I am aware, the following case by Le Dentu is the only one recorded in which the popliteal nerves have been injured in dislocation of the knee:

CASE VI.—*Le Dentu,†—Paralysis of the Internal Popliteal Nerve, following Dislocation of the Knee.*

On March 11, 1880, a man, aged twenty-seven, sustained a dislocation of both knees in a severe machinery accident. On the

* *Loc. cit.*

† *Bull. et Mém. de la Soc. de Chir.*, vol. vi. p. 591.

left side the tibia was partially dislocated backwards. On the right side the leg was rotated out and displaced forwards. The dislocations were readily reduced under chloroform, and cooling lotions were applied. All went well until March 26th, when it was noticed that there was partial anæsthesia of the right leg. Sensibility was normal in the left. On March 30th the patient suffered severe pains in both lower extremities, and *two sloughs* made their appearance quite suddenly, one—a superficial one—on the left calf, the other deeper, near the right tendo-Achillis. All pressure had been, and was still, carefully avoided, but the slough on the right side extended and caused partial destruction of the tendon. The appearance of the slough was soon followed by intense pain in the right leg of neuralgic character, with a sensation of painful swelling and darting pains, sometimes in the foot, sometimes in the leg. These troubles were worse at night, and the patient could not sleep. They continued until April 15th, in spite of treatment of various kinds, especially opium and chloral. On April 21st they reappeared with the same intensity. On April 24th a second slough showed itself on the head of the metatarsal bone. There was no pressure in this situation. At this time sensation, already slightly impaired, was absolutely lost in the right leg throughout the entire distribution of the internal popliteal nerve. On April 28th the pain permanently disappeared.

On June 19th the patient left the hospital, but in October he was again seen, and it was found that much *wasting* of the right leg had occurred, with *paralysis* of the *foot* and *toes*. Under treatment by electricity this paralysis improved, but when last seen had not disappeared. The knee-joints entirely recovered.

Treatment of Cases of Nerve Injury complicating Dislocations.—In these cases the treatment has to be considered in two classes of patients. First, those in which the dislocation has been reduced ; secondly, those in which it remains unreduced.

In the first class there is generally little to be done except to keep the paralysed parts warm, to apply galvanism regularly, and to have the limb thoroughly treated by massage. Any complications also should be treated as they arise. (See Chap. XIX.) The case may be simply one of contusion.

In the second class the treatment will differ with the circumstances of each case, and must depend upon the age of the

patient, the length of time that has elapsed since the accident, the amount of the paralysis, and the joint implicated.

Thus, in the case of the shoulder, if attempts at reduction fail, or are considered inadvisable, if the patient is old and the amount of the paralysis and of pain is slight, then it will probably be prudent to do no more than break down adhesions, encourage the use of the limb, and employ massage and galvanism.

If, on the other hand, the paralysis and pain are considerable, do not improve under treatment, and the patient is young and healthy, then, in the result of failure to reduce the dislocated humerus, it might be advisable to follow the treatment adopted by Mr. Sheild and excise the displaced head, as was done in the following case :

Sheild.—Paralysis from Pressure in a case of Unreduced Dislocation of the Shoulder.—Resection of the Head of the Humerus.*

In this case a man, aged forty-eight, suffered from paralysis of the muscles of the hand and forearm, resulting from the pressure of the head of the humerus, which had been dislocated eleven weeks previously. The dislocation was of the sub-coracoid variety, and after the failure of attempts at reduction Mr. Sheild excised the head of the bone with a satisfactory result. Such an operation appears to be justified when a sufficient amount of time has been allowed to elapse to admit of recovery, and the treatment has been recommended by other surgeons quoted by Mr. Sheild in his paper.

Each case, however, must be treated on its own merits, with due regard to the condition of the patient and the amount of his suffering. And it must further be clearly borne in mind that, even when there has been nothing more than contusion, paralysis of motion and sensation may persist for many months, and yet the patient may ultimately completely recover.

* *Trans. of Roy. Med. Chir. Soc.*, vol. lxxi. p. 173.

CHAPTER XVI.

COMPLICATIONS OF NERVE INJURIES.

Congestion and Inflammation of Nerves.—The complications that follow in the track of nerve injuries are sometimes very troublesome. Those of which I shall treat at present are mainly of an inflammatory character, and the first is congestion.

This subject has been studied experimentally by Waller and Mitchell, the method adopted by both being the application of a freezing mixture to the ulnar trunk at the elbow. The first result of this was a severe aching pain, chiefly in the ulnar distribution, but spreading also to neighbouring parts of the hand; this was followed by numbness, and finally by complete loss of all sensation, the hand growing hotter, and sometimes sweating. Muscular power was lost, and the ulnar nerve below the frozen spot became very irritable. The symptoms which persist after thawing are supposed to be due to "congestion" of the nerve, which remains sore for some distance above and below the elbow, a condition which may spread as far as the brachial plexus. In the peripheral distribution of the nerve, pricking, tingling, and numbness continued for a variable time.

As these symptoms are much the same as those which constantly occur in neuralgia, Mitchell concludes that in neuralgia the nerve is probably in a state of congestion.

The *pain* that sometimes follows in the wake of a nerve-injury varies both in kind and intensity. In a large number of cases there is but slight pain from first to last, but in many others pain of a shooting, burning, or pricking character is present. The burning pain has characters peculiar to itself, and will again be referred to, but the other pains are of a distinctly *neuralgic* nature, and are influenced by conditions similar to those which modify neuralgia. Thus, there are many who habitually suffer slightly, but in whom the symptoms are undoubtedly aggravated very largely by cold or

wet, a statement made with surprising unanimity by patients suffering from injuries of every variety, the most usual form of pain noticed under these conditions being of a numbing character. The scar marking the seat of injury most usually remains a tender spot, pressure upon which results in sudden, shooting pain, darting down towards the peripheral distribution of the nerve.

In some cases the pain appears to be of a remittent character, apparently uninfluenced by surrounding conditions, though sometimes coming on at regular intervals. The pain which is present in cases of punctured wounds of small branches has been already considered.

Mitchell, in his work on *Injuries of Nerves*, the larger number of which were caused by gunshot wounds, has described cases in which a peculiar burning pain of the most agonizing nature was present, and to which he has given the name of "causalgia." His description is so graphic that I shall venture to quote it at length, for this condition has barely been noticed by other authors:

"In our early experience of nerve-wounds we met with a small number of men who were suffering from a pain which they described as a 'burning,' or as 'mustard red-hot,' or as a 'red-hot file rasping the skin.' In all of these patients, and in many later cases, this pain was an associate of the glossy skin previously described. In fact, this state of skin never existed without burning pain. Recently we have seen numbers of men who had burning pain without glossy skin, and in some we have seen this latter condition commencing. The burning comes first, the visible skin changes afterwards; but in no case of great depravity in the nutrient condition of the skin have we failed to meet with it, and that in its forms of unendurable anguish.

"We have some doubt as to whether this form of pain ever originates at the moment of wounding; but we have been so informed as regards two or three cases. Certain it is that, as a rule, the burning arises later, but almost always during the healing of a wound. Of the special cause which provokes it we know nothing, except that it has sometimes followed the transfer of pathological changes from a wounded nerve to unwounded nerves, and has then been felt in their distribution, so that we do not need a direct wound to bring it about. The seat of burning pain is very various, but it never attacks the trunk, rarely the arm or thigh, and not often the forearm or leg. Its favourite site is the foot or hand. In these parts it is to be found most

often where the nutritive skin changes are met with—that is to say, on the palm of the hand, or palmar surface of the fingers, and on the dorsum of the foot; scarcely ever on the sole of the foot, or the back of the hand. When it first existed in the whole foot or hand, it always remained last in the parts above referred to as its favourite seats.

“The great mass of sufferers described this pain as superficial, but others said it was also in the joints and deep in the palm. If it lasted long it was finally referred to the skin alone. Its intensity varies from the most trivial burning to a state of torture, which can hardly be credited, but which reacts on the whole economy, until the general health is seriously affected. The part itself is not alone subject to an intense burning sensation, but becomes exquisitely hyperæsthetic, so that a touch or a tap of the finger increases the pain. Exposure to the air is avoided by the patient with a care that seems absurd, and most of the cases keep the hand constantly wet, finding relief in the moisture rather than in the coolness of the application. Two of these sufferers carried a bottle of water and a sponge, and never permitted the part to become dry for a moment. As the pain increases, the general sympathy becomes more marked. The temper changes and grows irritable, the face becomes anxious, and has a look of weariness and suffering. The sleep is restless, and the constitutional condition reacting on the wounded limb exasperates the hyperæsthetic state, so that the rattling of a newspaper, a breath of air, the step of another across the ward, the vibrations caused by a military band, or the shock of the feet in walking, gives rise to increase of pain. At last the patient grows hysterical, if we may use the only term which describes the facts. He walks carefully, carries the limb with the sound hand, is tremulous, nervous, and has all kinds of expedients for lessening his pain. In two cases, at least, the skin of the entire body became hyperæsthetic when dry, and the men found some ease from pouring water into their boots. They said, when questioned, that it made walking hurt less; but how or why, except by diminishing vibration, we cannot explain. One of these men went so far as to wet the sound hand when he was obliged to touch the other, and insisted that the observer should also wet his hand before touching him, complaining that dry touch always exasperated his pain. Cold weather usually eased their pains; heat, and the hanging down of the limb, made them worse. Motion of the part was unendurable in some

of the very worst cases ; but for the most part it did no harm, unless so excessive as to flush the injured region."

Some few of the cases that have come under my own notice have complained of "a burning pain," and it has occasionally been associated with "glossy skin," but I have never yet met with a patient in whom the symptoms at all approached in severity those described by Dr. Mitchell. And indeed I fancy they must be rare exceptions to the general rule of nerve-injury, for otherwise it is scarcely credible that they should almost entirely have escaped the notice of English surgeons. Paget indeed alludes to a burning pain as being present in some cases of "glossy skin," but from his manner of speaking of it the severity of the symptoms could not have approached that described by Mitchell.

Hamilton* details a case which in many respects resembles those of "causalgia" above referred to, though the results of treatment of a very simple kind appear to have been most satisfactory. He says : "The patient was under my care during Mr. Crampton's absence in England. He was a master butcher, and four years previously sprained his wrist in killing an ox ; soon after he became affected with pain in the wrist, coming on at night, and keeping him awake in the greatest agony for several hours, going off towards morning. The wrist during the paroxysm became pale red, and slightly swollen, perspired, and got so hot that he said it smoked. He used to have at his bedside a large pitcher of very cold water, into which he plunged his hand and kept it there with the greatest relief till the water became warm, when the pain returned. He had suffered constantly more or less violently for four years, and during that time had applied to nearly every man of eminence in Dublin ; and of course had been subjected to every variety of treatment that skill or ingenuity could devise, but with scarcely any benefit, as, when he came under Mr. Crampton, he occasionally suffered as severely as at first. There was no appearance of disease in the wrist-joint, and though he could use it for slight ordinary purposes, it was too weak for the usual violent efforts of his calling. After trying various things, Mr. Crampton recommended the part to be kept constantly wet with a strong solution of the acetate of lead ; it at once afforded marked relief, and at the end of ten days he was quite well, and had had no return when I saw him several months after."

* *Dublin Journal of Medical Science*, 1838.

This case, no doubt, belongs to the same class as those detailed by Mitchell, but it is the exception that proves the rule, and in the absence of additional evidence we must conclude that instances of "causalgia" are rare.

My own observations also do not lead me to entirely agree with the statement made by Mitchell, that "this state of skin [glossy skin] never existed without burning pain." It is true that pain is present at first, but where the abnormal condition of the skin lasts many years, my own experience is that the pain gradually departs, so that the ultimate prognosis is fairly good.

Before leaving this subject, I may remark that in all cases of severe pain following a nerve-injury there is, I believe, some abnormal condition of the proximal end, generally of the nature of a sclerosis, and that neuralgic and burning pains are seldom present without some inflammatory condition of the affected trunk. Further, all painful states are undoubtedly exaggerated by any condition of ill-health, which they in turn tend to set up.

Traumatic Neuritis.—That nerves are liable to congestion and inflammation like all other tissues might fairly be expected, that they are, however, in spite of their delicate structure, not very easily or very frequently damaged, is not by any means so probable at first sight. But, considering the many wrenches and strains, as well as, in some places, the direct injuries to which the nervous trunks are exposed, it becomes very certain that they do possess a considerable amount of resisting power, and are not prone to become easily inflamed. The pathological conditions arising from congestion and inflammation have been described by various authors, and may be observed in the vicinity of any large wound, more especially if it has taken on an unhealthy action. Under such circumstances the nerve becomes swollen, soft, and of a pinkish hue, more succulent than natural, and perhaps infiltrated with a little pus. A microscopic examination shows enlargement of the blood-vessels, collections of white cells in the perineurium, and gradual disappearance of myeline. With regard to inflammation, Mitchell† says: "The primary effect of inflammation of a nerve is to cause an enormous development of its connective-tissue elements, and at first to render the nerve less firm, owing partly to this hyperplasia, and partly to an effusion of serum within the nerve-sheath and between the nerve-fibres."

* *Op. cit.*, p. 68.

Cornil and Ranvier, in their recent work on Pathology (1882), give the following account :

“Congestion of nerves occurs rather frequently, as is seen in all nerves implicated in an inflammatory focus ; it may often extend beyond this focus ; in phlegmon of the leg, for example, it is not rare to find congestion of the sciatic nerve extending as far as the sciatic notch. On carefully dissecting the nerves involved in a wound, they are found to be slightly swollen, and upon their surface are seen red lines parallel to their axis, which indicate that congestion occurred during life.

“Hyperæmia particularly affects the peri-fascicular vessels, and may be easily recognized ; hyperæmia of the intra-fascicular vessels may also exist, but it is not so easily recognized by the naked eye, for the laminated sheath must be stripped off before the vessels filled with blood can be seen in the nervous fasciculi. To estimate the dilatation of the capillaries, transverse sections of the nerve should be made after hardening in chromic acid. Thus, in a transverse section of the internal saphena nerve, in a soldier who was suffering from a wound of the leg produced by the explosion of a shot, the intra-fascicular capillaries were found dilated and full of blood.

“In deep whitlow we have seen the collateral nerves present a similar lesion, and it is very probable that intra-fascicular hyperæmia of nerves is an important cause of the acute pain accompanying this lesion. Congestion of nerves causes an increase of the blood tension, and serous exudation into the peri-fascicular connective tissue ; miliary hæmorrhage may also be produced. More extensive blood foci may be found when the nerves are denuded, as in wounds, for example.”

The same authors remark that suppuration in nerves is extremely rare, and suggest that the laminated sheath presents an almost insurmountable barrier to the diffusion of pus into the interior of the fasciculi ; even in the midst of suppurating tissues the nerves may preserve their functions. In chronic inflammation, “the new cell formation being continued into the peri-fascicular connective tissue, and between the laminæ of the laminated sheath of the nervous fasciculi, separates them, compresses the fasciculi, and the nerve-fibres undergo below the diseased spot the series of changes which are observed in the peripheral end of a divided nerve.”

Rokitansky describes acute neuritis as resulting in a rapid destruction of the nerve, which becomes of a yellowish-red colour and

very friable. Its tissue becomes infiltrated with bloody pus, and abscesses form around it. If the inflammation is less acute, the nerve becomes "at first oedematous, dotted with small extravasations, and very hyperæmic. The surrounding tissues become involved, and are matted together with the nerve by the inflammatory products which may or may not be subsequently absorbed."

As in other tissues so also in nerves, the more chronic the inflammatory process the greater is the tendency towards the development of the inflammatory products, and thus in chronic neuritis there is found a general enlargement of the nerve due to the growth of fibrous tissue between the fasciculi. A transverse section of such a nerve placed under the microscope will show that there is first of all an increase of the perineurium, and that the bundles are simply separated from each other by more tissue than is found in a healthy trunk. Next, the endoneurium becomes hypertrophied, and the nerve-fibres are individually separated from each other and no longer appear to be collected into bundles. Finally, the nerve-fibres themselves being compressed by the growth of the new tissue, and having their nutrition interfered with, undergo slow degenerative changes, with loss of myeline, multiplication of nuclei, and subsequent destruction of the axis cylinder, changes precisely similar to those observed in the peripheral end after section. The inflammatory changes spread to the loose cellular tissue in which the nerve lies, and adhesions slowly and steadily form, compressing and limiting the movements of the trunk, and so keeping it in a permanently irritable state.

In chronic inflammation, Mitchell describes the nerve-trunk as being irregularly vascular, enlarged in some places, and smaller than it should be in others. "The induration which affects more or less the whole of the inflamed portions varies in density, so that sometimes there is a long firm swelling of an inch or more of nerve, or else in a part moderately hard there is a succession of firm little fibroid bodies imbedded, and around them a circle of greater vascularity than elsewhere. The colour of the nerve is usually some tint of grey, or pale lead colour, and in all probability the tact corpuscles undergo enlargement and degeneration. The tendency of these cases is rather towards hypertrophy and hardening of the connective tissue of the nerve, and also, as a rule, the morbid change tends to march from extremity to centre, rather than outwards. The result of these alterations is a gradual increase of white connective tissue, a con-

sequent thickening of the sheaths, and finally a more or less complete atrophy of the nerve-tubes, involving chiefly the white substance of Schwann and leaving the nerve-fibre a mere rod, hardly to be distinguished from the more wavy fibrous tissue about it. This destruction is rarely complete throughout the nerve, so that nearly always nerve-tubes in every state of health and degeneration can be seen within the area of a single inflamed and hardened nerve."

"I have met with perfectly healthy nerve-tubes in a nerve which was as tough as a tendon. With every appearance of enlarging, such nerves are actually undergoing atrophic changes as to their proper tissues."

Such, then, are the pathological changes that a nerve undergoes when the seat of inflammation resulting from injury. Clinically, cases of neuritis may be divided primarily into acute and chronic, a division which tallies with the pathological conditions already described; and secondarily, these divisions may again be subdivided into localized and spreading neuritis. Of the changes that occur in the localized variety I have no more to say, but the tendency of neuritis to spread along the nerve-trunk is, in some cases, a most serious evil.

In such cases the inflammatory processes already described spread more particularly along the central end towards the spinal cord, and in this way the neuritis may affect the other trunks of which the inflamed nerve is a branch, and may also reach as far as the spinal cord itself. The changes that occur in the nerve-trunk will depend upon whether the neuritis is acute or chronic. The latter is by far the more common.

Any injury to a nerve may set up neuritis, yet in my own experience the complication is certainly a rare one, although for some five or six years past I have been constantly on the look-out for examples. It is considered by some authors to result more frequently from contused and lacerated wounds than from clean-cut ones. This is certainly plausible, yet it may follow clean incision, as when it attacks a stump. Exposure to cold, and a septic condition of the wound, are also quoted as exciting causes.

Extension of inflammation from surrounding parts very rarely causes neuritis. I have seen a sciatic nerve bathed in pus for months without showing any sign of inflammatory change, and it would almost appear that in order to start a neuritis the nerve-sheath must be damaged. The length of time that elapses between

the injury and the neuritis is very variable. In acute cases a few hours only may intervene. In chronic ones symptoms may not occur for weeks or months.

Symptoms of Acute Neuritis.—The symptoms accompanying this condition appear, as a rule, to be ushered in by a rigor, followed by a rise of temperature and well-marked feverish symptoms. *Pain* at the same time commences at the seat of injury, and gradually spreads, not only along the damaged nerve, but is also felt in neighbouring trunks. In many cases the *muscles* are the seat of spasmodic twitchings, spasms, or fibrillar tremors. Gradually they lose their power, and finally may become completely paralysed. Rapid atrophy and degeneration of the muscular fibres keep pace with the above changes, and an examination by electrical reagents will show a partial or complete loss of faradic contractility, with, at a later date, similar changes in the reaction to galvanism. *Trophic changes* such as I have already described may occur in the parts supplied by the inflamed nerve, and may extend to other parts as fresh nerve-trunks become implicated locally. The nerve-trunk may be felt enlarged and hardened, extremely sensitive to pressure, and the skin over it red and hyperæsthetic. This condition of the nerve-trunk indeed affords by far the most important positive evidence of neuritis, for it must clearly be understood that pain or tenderness alone in the course of a nerve does not necessarily imply inflammation, such symptoms being often present in neuralgia without there being any sign of neuritis when the nerve is actually examined.

In cases of spreading acute neuritis the same symptoms occur, but gradually extend over a larger area as fresh nerve branches or trunks are implicated. Thus, a neuritis with functional disturbance in the area of distribution of the median nerve, may, by an extension of the inflammation to the brachial plexus, subsequently cause paralysis and pain in the ulnar or musculo-spiral distribution. The severity of the symptoms will thus to a great extent depend upon the extent of the mischief. The pain appears to be usually most severe soon after the neuritis has commenced, and probably subsides in proportion to either the actual destruction of the nerve-fibres or else the subsidence of the inflammation. The length of time over which the whole attack may spread is somewhat variable, as is also the final result, for the patient may entirely convalesce or chronic neuritis may ensue.

I have seen no description of acute neuritis in the writings of

English surgeons, but cases are recorded by continental writers, and more especially by Mitchell, in his work to which I have already alluded. To this latter I would refer for details of cases which I cannot quote here, and shall satisfy myself for the present with giving one as a specimen :

“ J. C., sergeant, consulted me on account of loss of power in his arm with severe neuralgia. At Gettysburg he received a ball wound in the left neck, splintering the clavicle and emerging through the trapezius. Some fragments of bone were lifted out of the wound, which did well until a week later, when on the way to Washington he was suddenly taken with a chill of some severity followed by high fever. At the same time the whole arm began to ache, darting pains shot up and down it, and the skin on the inside of the arm below the axilla was seen to be red ; the nerve-tracks were extremely tender. On the third day the whole arm was somewhat swollen, and the darting and aching pains were only subdued by frequent hypodermic injections. His first notable relief was obtained by an application of cut cups to the neck and shoulder, and gradually the pain lessened to its present grade of severity. The ulnar and median were hard, enormously enlarged, and very tender. J. C. described himself as having been made delirious by the earlier pain of his disease ; and even when seen by me, after it had abated, he showed very plainly that the mind as well as the body was affected, his memory being impaired, and his temper excessively irritable.”

In this case, as in many others, there can be no doubt that the inflammation left the nerves permanently damaged and probably thickened, so that the tubules were compressed and separated from each other, as already described.

The account of a less severe case is given by T  rillon.* The patient had sustained a contusion of the forearm. This was followed by much pain, and fifteen days after the injury the median and ulnar nerves were found enlarged and tender, not only at the seat of injury, but for some distance above. Six weeks later most of the symptoms had passed off, but the ulnar nerve remained enlarged.

Symptoms of Chronic Neuritis.—In describing the pathological changes that occur in chronic neuritis, I have said that those which are the most notable are the gradual thickening

* *Bull. de la Soc. de Biol.*, 1877.

of the nerve by the formation and organization of inflammatory products, and the gradual tendency exhibited by these changes to spread up the affected trunk towards the nervous centres. The earliest symptoms of this affection are pain and tenderness along the damaged nerve, with a slight amount of enlargement and hardening; numbing and tingling pains follow in the periphery, and are liable to frequent exacerbations. In addition to these, a persistent aching appears, which is constantly present, but often is most troublesome by night. The skin is occasionally hyperæsthetic in spots, sometimes to a very marked degree. Various trophic changes may also be present. The muscles supplied by the inflamed nerve are frequently at first the seat of tonic or clonic spasms with fibrillar twitchings. Later on they gradually waste and become paralysed, whilst at the same time their faradic and galvanic irritability decrease.

As the neuritis spreads upward, other skin areas and muscles become affected, the former tenderness of the originally affected nerve passes away—for its nervous structure is gradually destroyed—and other trunks become in turn inflamed, tender, and enlarged, and also in time undergo a slow degeneration.

The following cases illustrate most of the points I have mentioned. The first two are recorded by Mitchell :

“A man, aged forty-four, bruised his right ulnar nerve on July 12, 1862. A year later there was loss of power in the ulnar distribution, together with impairment of sensation and atrophy of the affected muscles. Under treatment he at first improved, but took to drinking, neglected all care, and five months later the paralysis had spread to the flexors and extensors of the forearm; both ulnar and median nerves were tender on pressure, and the atrophy of the muscles was advancing. There can be little doubt that the neuritis had spread up the ulnar nerves and affected the other trunks.”

“S. W., aged thirty-three,* received a bullet wound below the left clavicle in August 1862. There were immediate symptoms of injury of the external anterior thoracic nerve, indicated by paralysis of the great pectoral muscle, but motion and sensation were normal in the arm and forearm. Power in these parts, however, gradually diminished, and on Feb. 19, 1864, the biceps and some of the muscles of the forearm were all found more or

* *Op. cit.*, p. 314.

less atrophied and paralysed. This condition was probably due to a gradual implication of the other nerve-trunks in the vicinity."

Drs. Sands and Seguin* describe the condition of the nerves of a brachial plexus which had become the seat of an ascending chronic neuritis, as a result of a rupture of these cords. The nerves examined were removed from close to the cervical part of the spinal cord. "To the unaided eye, they appear like sections of some dense indistinctly fibrillated tissue, tendon for example. Under a low magnifying power the general sheath of the nerve is seen very much hypertrophied. The secondary fasciculi vary immensely in size and appearance. A few are still rounded, encircled by a distinct sheath, and fairly filled with nerve-fibres in better or worse condition. The majority, however, are broken up into innumerable smaller bundles, the separation being effected by the formation of distinct bands of fibrillated connective tissue in the place of the scanty network described as lying between the fibres in a normal section. Between many of these fragmented fasciculi are large masses of wavy, dense connective tissue, with abnormally large vessels, and with a great quantity of granular pigment deposit. This yellowish pigment lies principally immediately around the vessels, or in the connective tissue near them.

"As regards the nerves themselves, it may be stated that they are in a state of atrophy. In one fasciculus, for example, there are very few fibres which present the circular outline, hyaline mass, and eccentric dot characteristic of the normal fibre seen in transverse section.

"The vast majority are much smaller than usual (appearing of about the same dimension with 300 diameters as normal fibres do with 45); they vary immensely in diameter, and many are represented only by parts of small circles. No masses of embryonic cells are seen in any part of the preparations. Fig. 3 is drawn from a preparation from the eighth cervical and first dorsal nerves under a power of 300 diameters, and exhibits very fairly the condition existing in one of the best prepared parts of the section. One large fasciculus is quite entire, though the majority of fibres composing it are shrunken and empty. Above this fasciculus are very heavy masses of connective tissue, which are closely connected with the perifascicular sheaths.

* *Archives of Scientific and Practical Medicine*, New York, 1873.

“To the left of this fasciculus is seen a blood-vessel having round about it much yellow pigment. . . . Another fasciculus is broken up into tertiary fasciculi by increase of connective tissue, in some places single fibres are seen surrounded by dense connective tissue. In other parts of the preparation more extreme changes were to be seen, in some fasciculi nearly every fibre being separated from its neighbour by newly formed fibrillar substance.”

The patient from whom these nerves were removed had been suffering from the most severe pain in the arm for many months. The pain was apparently of a neuralgic nature, and was so extreme as to necessitate amputation. Even after this the pain continued, and for its relief neurectomy had subsequently to be performed. The part from which the thickened portions of nerve were removed was considerably above the seat of the original injury.

The following description by Mr. Langstaff* affords a very good instance of chronic neuritis, spreading centripetally, set up by a sprain :

“F., aged twenty-three, fell and injured her wrist ; she was immediately rendered incapable of straightening the fingers. Great effusion took place, which was succeeded by inflammation and swelling of the whole of the hand and arm, which symptoms were not easily subdued. Every endeavour was employed to recover the power of the fingers and movement of the carpal articulation without effect. The flexor muscles and tendons were in rigid action, and the finger-ends drawn closely to the palm of the hand. The patient continued to experience great pain, and the limb was useless. . . . Her health became affected, and she suffered not only great misery from the painful sensation in the arm, but also from the local means employed in the recovery of the use of the fingers.

“All endeavours proving fruitless, amputation was proposed and agreed to. The stump, I understand, did not unite favourably ; and she suffered distressing agony, which affected her health so that she became extremely nervous.

“When I saw her the surface of the stump presented an unfavourable appearance, the skin covering the ends of the

* *Med. Chir. Trans.*, vol. xvi.

radius and ulna was very thin, excessively vascular, and the ends of the bones seemed likely to cause its absorption. There was also a constant state of convulsive action of the muscles of the stump, accompanied with agonizing pain. . . . She was hysterical, and the paroxysms were frequent; the spasmodic affection of the muscles became more evident, and a pulsation almost aneurysmal could be seen and felt at the extremity of the stump."

Amputation was performed, and the nerve-ends were cut very short. "In this preparation the median, radial, and ulnar nerves are shown, which are remarkably large, the extremities of the two latter being greatly increased by deposition of organized lymph. The patient was relieved of all the painful sensations she had so long been distressed with, had no recurrence of hysteria or convulsions, her health improved, a good stump was effected, and she is now able to gain her livelihood."

In the following cases the original injury was very slight, and the spread of the neuritis very marked:

CASE I.—*Charcot*.^{*}—A man, aged thirty-two years, sustained an injury whereby the last phalanx of the index finger of the left hand was avulsed. The end of the finger was reappplied, but sloughed in a few days. The accident happened on Oct. 2, 1875, and on Oct. 7th the patient first complained of pains in the injured part. The wound healed by November, but from the end of October the pain in the finger became more severe, and extended over the back of the hand and along the outer side of the forearm as far as the axilla. The pain was of a shooting character and intermittent. Pressure on the back of the index finger and on the back of the hand was painful. There was no alteration in sensation, and no trophic changes in the skin. The radial nerve in its whole extent was tender. There were no spasms or contractions. On Nov. 5th the patient had an attack of more severe and diffused pain than he had formerly suffered. At the end of November muscular spasms and twitchings made their appearance in the arm. On Dec. 7th a more severe attack of pain than any of the preceding ones was experienced, and was accompanied by spasms of some of the muscles of the neck. The

^{*} *Archiv. Gén. de Méd.*, Dec. 1885.

following day the pain still continued. On Dec. 9th the patient experienced a similar attack, during which there was spasmodic closure of the jaws. On Dec. 11th a portion of the radial nerve was excised close above the wrist. It was found to be in a state of sclerosis, there being an increase in connective tissue and a diminution in the nerve-fibres. The operation gave immediate relief to the more severe symptoms, and on Dec. 31st the patient left the hospital. On Feb. 27th of the next year he had an epileptiform seizure. Similar seizures occurred at intervals of about six weeks, then gradually became weaker, and in two years the patient died.

CASE II.—*Charcot*.—A patient, who had on four previous occasions been operated upon for a keloid growth on the left side of the neck, was admitted into hospital on Oct. 17, 1878, with a recurrence of the growth. At this time the scar was found to be very tender, and on the least contact the muscles of the left side of the neck contracted. The patient said that ever since the last operation—a year previously—he had suffered from gradually increasing pain of a shooting, cutting, or burning character, which extended from the neck to the head and to the inner side of the arm. The skin for some distance around the keloid growth was hyperæsthetic, the hyperæsthesia extending as far as the shoulder. The patient said that the arm had been getting weaker for a year past, and on admission he was unable to use any of the muscles inserted into the humerus. They contracted, however, to electrical stimuli. There was some atrophy of the paralysed muscles. There were no trophic changes.

CASE III.—*Charcot*.—In Oct. 1877, some strumous glands were removed from the neck of a patient, aged twenty-three years. The operation was followed by severe pains in the neck and arm of the side operated upon. A year later there was considerable atrophy of the muscles of the shoulder.

CASE IV.—*Charcot*.—A soldier, aged twenty-two, in good health, received a severe contusion on the outer side of the left leg, accompanied by much pain. The patient immediately noticed some numbness in the four outer toes on their dorsal surfaces. The day after the injury (Oct. 22nd) there was severe neuralgic pain extending along the course of the external popliteal nerve. On Nov. 2nd

painful spasms in the affected limb. On Nov. 5th extreme pain on pressure over the seat of contusion, which corresponds to the point of exit of the musculo-cutaneous nerve. The external popliteal and sciatic nerves are also tender on pressure. Complete anæsthesia and analgesia of the foot in the parts supplied by the musculo-cutaneous. Pain in all the toe-joints. From this time, under treatment at first by opiates, and afterwards by electricity, the symptoms gradually subsided.

Vulpian.—Neuritis of the Right Ulnar Nerve with Muscular Atrophy following an injury.

The patient was a gendarme, aged thirty-five, who had suffered from symptoms of paralysis for more than twelve years. In 1864, in the spring-time, he woke one morning and found it impossible to move the right arm, and felt at the same time a severe pain in the elbow, forearm, and hand. Whatever might be the cause, the patient was not able to get rid of this pain; in fact, the following days he felt painful cramps in the forearm, fingers, and the hands. In addition, he had contractions of the forearm that violently flexed it upon the arm. At the same time he had painful sensations of tingling and swelling on the inner part of the hand and the ring and little fingers. The posterior part of the elbow was the seat of severe pain. The patient also felt, in the early days of his illness, a sort of firm, hard cord behind the elbow in the region of the ulnar nerve, pressure upon which was very painful, and caused shooting pains in the ring and little fingers. This state lasted about three weeks, and the contractions and pains rendered the use of the hand almost impossible. No treatment was pursued, but gradually the pains at the elbow and in the hand lost their intensity, the cramps became more rare, and the patient gradually resumed the use of the hand and believed himself to be getting cured. Meantime, from time to time painful tinglings reappeared in the hand, and the cord which he had noticed behind the elbow remained painful to touch for a long time. It was not until after fifteen months that the patient noticed the wasting of the right hand. On being examined in August 1877, the patient was found to be a well-built, healthy man, with good general health, who only complained of weakness in the little and ring fingers and palm of the hand. The painful tinglings, which were formerly frequent, had almost entirely disappeared

and only made themselves apparent at rare intervals. At the same time they could be brought on by pressure exercised upon the ulnar nerve behind the elbow. In this situation one could feel a distinct hard cord, and there could be no doubt that the right ulnar nerve at this place was certainly larger than the left. Sensibility seemed to be intact in the forearm, but was diminished in the hand and the fingers supplied by the ulnar nerve. Thus, when one pricked this part with a needle, the patient said that he felt it less plainly than in the left hand. There were at the same time some troubles of mobility, and there was considerable atrophy of the greater number of the muscles of the hand supplied by the ulnar nerve, and more especially there was atrophy of the interosseous muscles. All the fingers had a slight deviation towards the ulnar side. The two last phalanges of the little and of the ring fingers were slightly flexed upon the first. These phalanges of the other fingers remained habitually extended in the attitude which the hand naturally takes when at rest. There was complete atrophy of the muscles forming the hypothenar eminence, and that part of the thenar eminence which is formed by the muscles supplied by the ulnar nerve. The movements of the fingers were feeble, more particularly the movements of adduction and abduction. The patient did not remain in the hospital, and the final termination of the case was not known.*

Disease of the Spinal Cord, consecutive to Neuritis.

—Very rarely indeed does neuritis extend to the spinal cord, yet I do not think there can be any doubt that in some instances such an unfortunate sequence has ensued.

The earliest reference to such a complication, is by Charcot :†—“The patient was a man, aged forty-two, who in 1852 had an inflammation of the forearm, necessitating five incisions. In one of these the radial nerve was probably injured, and anæsthesia of part of the forearm and hand, with neuralgic pains and great tenderness of the scar, supervened. On the back of the hand and of the middle and ring fingers trophic lesions with a bullous eruption followed. Two years later, the arm and forearm of the *other side* gradually became weak and atrophied. This was followed by tingling and numbing pains in the hand, and finally by anæsthesia.”

Mitchell (at page 302 of his work already quoted) describes

* *Clinique Médicale de la Charité*, p. 919.

† *Journ. de Phys.*, 1859.

the case of a man, who, after a gunshot wound of his axillary plexus on the right side, suffered from symptoms of neuritis, and subsequently from trophic lesions in the left hand, with hyperæsthesia.

Fraglemann,* in 1877, described a case of neuralgia of the stump of a leg, in which seven years after amputation spasmodic movements gradually spread from the leg to the thigh, and then to the arm of the same side. Neurectomy of the tibial nerves was of no avail, and a month later the patient died, apparently as a result of the convulsions which seem to have become general. No post-mortem examination was allowed.

Charcot, in 1880,† said that he had seen a case in which, after severe neuralgia of the stump of a thigh, paralysis of the bladder and subsequently of the opposite lower extremity, ensued, due apparently to myelitis.

It will thus be seen that in some few instances the symptoms of spreading neuritis would seem to have been followed by other symptoms referable to an inflammation with sclerosis of the spinal cord. In one case this was unilateral and affected the arm and leg on the same side. In other cases the myelitis seems to have been transverse, and to have caused symptoms in the corresponding limb on the other side of the body.

At present there are no recorded cases of post-mortem examinations on patients who have presented during life symptoms of myelitis, secondary to ascending neuritis, and the actual lesion requires still the support of such evidence.

Treatment of Neuritis.—In cases of acute neuritis anti-phlogistic remedies are obviously indicated. Complete rest, the application of cold in the shape of ice-bags, or evaporating lotions, and local depletion by leeches and cupping, all appear to be of use. Where pain is severe, opium or other sedatives are indicated, whilst quinine, and in some cases mercury, appear to have been beneficial. I have not myself seen any case of acute neuritis, and am therefore dependent upon the statements of others.

Cases of chronic neuritis seem to demand a similar treatment to cases of chronic inflammations of other parts. The internal administration of mercury, or of the preparations of iodine, the local applications of counter-irritants, vesicants, or sedatives, should all be adopted.

* Quoted by Nepveu, *Rév. de Chir.*, 1881, p. 22.

† *Ibid.*

In addition, much good appears to have resulted, in some instances, from the application of galvanism or faradism, the use of which should not be given up until after a thorough and lengthy trial.

Lastly, operative measures may be required. Of these, I think the most important is the removal of any local cause of irritation. Thus, painful or irritable scars should be excised, foreign bodies should be removed, and if the nerve be subjected to any pressure it should be freed. (See "Varieties of Nerve Injuries.")

Supposing that no benefit results from such treatment, the inflamed trunks should be exposed and thoroughly stretched in some part of their course. I have already detailed cases in which this course has been adopted, and for further information would refer to other chapters, and more especially to those on "Neuralgia," and on "Nerve-Stretching." I think that in all cases nerve-stretching should precede neurotomy or neurectomy, and, especially in the case of motor nerves I would endeavour to postpone the infliction of so severe an injury as is caused by either of the latter operations as long as I possibly could, so as to allow time for this treatment to be given a fair trial.

Lastly, in some of Mitchell's cases the only relief was afforded by amputation, a termination which sufficiently emphasizes the reality and severity of the patient's sufferings.

CHAPTER XVII.

REFLEX PARALYSIS.

THE subject of reflex paralysis is one that has for long been of very obscure nature, and, although of late years some light has been thrown upon it, much yet remains to be discovered. By the term reflex paralysis is understood a paralysis of one part of the body due to an injury of another part. The paralyses may be divided into two classes: first, those in which the symptoms supervene immediately upon the injury; and second, those in which an interval of varying length intervenes between the injury and the paralysis.

The following cases by Mitchell are instances of the first class:*

“Case 22.—Ball wound of right neck, probably involving no important nerve directly; fracture of hyoid bone; reflex paralysis of left arm; probable reflex paralysis of right arm; early recovery of left arm; more remote and nearly complete recovery of right arm.”

“Case 23.—J. D., flesh wound of thigh without injury of large nerves; complete paralysis of all four limbs; left arm recovered quickly; the other limbs slowly; final development of myelitis.”

“Case 24.—W. W., wound of right thigh with probable injury to sciatic nerve; partial palsy of right leg; reflex paralysis of right arm, which recovered rapidly.”

The following are additional examples of similar sudden paralysis:

Bidon.†—A soldier, aged twenty-four, was shot in the lower end of the right femur. This wound was immediately followed by weakness of the right arm, with which nevertheless he was able to use his sabre. The leg was saved, although there was suppura-

* *Op. cit.*, p. 145.

† *Revue de Médecine*, 1884, p. 335.

tion in the knee-joint. A month after the accident the right arm became heavy and tingling. In a few days it became paralysed and anæsthetic. Under treatment by electricity the paralysis completely passed off.

Lepine.^{*}—A patient who had suffered from empyema was tapped on the 28th of August 1884. Immediately afterwards the right arm became weakened and heavy. There was no pain. The muscles became flaccid, and in November became atrophied, the patient being unable to put his hand to his head. There was slight power of movement of the hand, wrist, and elbow. Thus the movements of the arms were limited by great pain, although the shoulder-joints appeared normal. There was diminution of faradic contractility, but there was no anæsthesia. There were severe pains shooting from the puncture towards the shoulder and right arm, but they never affected the forearm and hand. This condition lasted for some months and then the patient completely recovered.

Lepine.[†] (Case 2.)—A patient with pleurisy was tapped in March 1873, and iodine was injected into the pleural cavity. At the very moment when this injection was made the patient felt a sharp pain and tingling in the limbs, especially in those of the right side, which lasted an hour and then gradually passed away. Some days afterwards the right upper extremity became gradually weak. On the 8th of June the empyema was again tapped. Three months afterwards he noticed weakness of the right lower extremity, this passed off gradually, and on the 20th of June he left the hospital without paralysis. After two months he returned with a sinus still remaining in the chest. This was treated with nitrate of silver injections, and after each injection there was some difficulty in the pronunciation of words. In Nov. 1875, there was still some feebleness of the limbs on the right side.

In two cases recorded by Mitchell there was a reflex paralysis of sensation, but not of motion. The anæsthetic area corresponded to the situation of the wound in the injured limb. The following case by Malecot is another example of reflex anæsthesia:

^{*} *Mémoires de la Soc. des Hôpitaux de Paris*, 1875, p. 122.

[†] *Revue de Médecine*, 1884, p. 341 (quoted by Bidon).

Malecot.—Reflex Anæsthesia of the Shoulder and of the Forearm, resulting from a Wound of the anterior fold of the Axilla.—Cure by application of Blisters over the Cicatrix.*

A woman, aged thirty-seven, was admitted into the Hospital under Mons. Auger. On the 30th of November she had received a wound in the anterior fold of the axilla with a knife. The depth of the wound was uncertain, but it was followed by no hæmorrhage of any importance. It was two centimetres in length, and was situated three fingers-breadth below the clavicle. The accident took place at two in the morning, and the patient was not seen until eight the following morning. At this time it was noticed that the parts immediately around the seat of injury were anæsthetic. This area of insensibility was limited by a line passing two centimetres from the inner end of the clavicle downwards along the edge of the sternum; then passing downwards three centimetres above the right breast, into the axilla and along the thorax, and finally running upwards to the scapula. The anæsthetic area, in fact, included the whole scapular region, the subclavicular region, the axilla, and a small portion of the thorax. The arm and the upper part of the forearm were in a similar anæsthetic condition. All movements were natural. There was no paralysis, the patient showed no signs of hysteria, and the wound healed by the 31st of December, but up to this date the loss of sensation remained unchanged. On the 6th of January the patient was again seen in a similar condition, she complained, however, of pain in the region of the shoulder. On Feb. 2nd, a blister was applied in the region of the scar. On the following day there was some return of sensation in the forearm at the posterior part of the elbow and on the inner side of the arm. Two more blisters were subsequently applied, and on the 16th of February the anæsthesia had gradually but almost completely disappeared, the only part which remained insensitive being the skin in the neighbourhood of the cicatrix. On the 26th of February the patient was well.

The pathology of such cases of reflex paralysis has been discussed by various authors, but without any satisfactory conclusions being drawn. Brown-Séquard† has suggested that the paralysis is due

* *Comptes Rendus de la Société de Biologie*, 1881-2, vol. iii. p. 124.

† *Leçons sur les Paralysies des Membres inférieurs*, 1854.

to spasm of the vessels in certain areas of the cord, but this theory has not received support from other investigators.

Mitchell, with more plausibility, considers that it is due to exactly the same conditions as give rise to the general paralysis met with in severe shock, and adduces in support several cases in which severe shock followed nerve wounds.

After all, however, this theory does not in any way add to our knowledge of the mechanism of reflex paralysis; and I can only regret that I have nothing more satisfactory to put in its place. That reflex paralysis is a reality I do not doubt, and am of opinion that it is better to own to ignorance of its real pathology than either to deny its existence as some authors have done, or to rest satisfied with some plausible theory. It is by careful and impartial investigation of future cases that the truth is most likely to be attained.

In the **second class** of reflex paralysis the symptoms do not supervene until some time has elapsed since the accident. The length of time is very variable, and the onset of the symptoms is often gradual. In many instances the paralysis is progressive. Before discussing the pathology of this variety, I will briefly relate some typical cases.

Punctured Wound of a Branch of the Median Nerve.—Reflex Paralysis and great Pain.

James S., aged forty-six, a butcher, fell through a skylight in March 1882, and cut the dorsal surface of the first interosseous space close to the web. The wound bled much and was dressed at the hospital for four months. The hand and arm were fixed in a splint, and when this was removed the patient found the fingers and thumb numb and stiff. Sensation was impaired.

Dec. 13, 1883.—His condition was as follows: A small scar in the first interosseous space close to the free edge of the web. Sensation: Impaired in the index, middle and ring fingers, and the thumb, but nowhere absent. Muscles of the ball of the thumb wasted and paralysed, and do not act to faradism or galvanism. The last phalanx of the thumb is partly ankylosed and doubled in.

Oct. 6, 1884.—He is worse. The thumb is extremely painful and tender at the tip. The muscles are wasted, and there is but slight reaction of the opponens to faradism and galvanism. Joint of the thumb still stiff. Sensation: He says the whole hand is

numb, the fingers supplied by the ulnar nerve being affected as well as those supplied by the median. He feels as if the hand were asleep; he can, however, localize everywhere. Trophic: The fingers are tapering and smooth, the joints of all are more or less stiff, so that he cannot make a fist. The ulnar muscles react to faradism, and he has power over them.

March 27, 1885.—Has improved slightly. All the muscles of the hand react, though feebly, to faradism.

July 7th.—He has been steadily galvanized for several months, there is some improvement, but the tip of the thumb is still so painful and hyperæsthetic that he can hold nothing and cannot do his work.

Sept. 13th.—No better.

*Wound of Median while opening an Abscess.—Gradual Recovery.
Slight Reflex Paralysis.*

T. R. was admitted, under the care of Mr. Smith, into Henry Ward, St. Bartholomew's Hospital, on Dec. 6, 1882. An abscess had been opened above the annular ligament a few days before admission, and he had had partial loss of sensation in the parts supplied by the median nerve, as well as paralysis of the muscles of the ball of the thumb.

Oct. 6, 1883.—There is slight voluntary action of the muscles of the thumb, and reaction to galvanism and to faradism.

Dec. 6th.—The hand is very slightly wasted, the grip is feeble. The fingers are cold, the nails striated. The hair is normal, and he has good power over the opponens and abductor pollicis, and sensation is good all over the fingers.

July 24, 1884.—Electrical examination: No reaction of degeneration. The muscles of the ball of the right thumb do not contract so well as those of the left, but they do contract to faradism and to galvanism.

April 23, 1885.—The muscles of the ball of the right thumb contract readily to faradism, but yet not so readily as those of the left. Sensation is normal.

Sept. 24th.—The hand is quite natural, except that he now has inability to flex completely the second and third phalanges of all the fingers and the terminal phalanx of the thumb. There is *paresis of the long flexors of the fingers and of the thumb*, a condition which may have been present all along, but which has not

previously been noted. Electrically examined, these muscles do not act well to either faradism or galvanism.

Bidon.—Paralysis from Peripheral Irritation.*

A man, aged forty years, of good general health, sustained two lacerated wounds in the gluteal region, immediately behind the anus. The wounds were treated with cold water and perchloride of iron, and at first all went well. The accident happened on Jan. 14, 1883. Ten days later some small pustules appeared on the inner side of each thigh, about three millimetres in diameter. They rapidly developed and burst, but by the middle of March they had all disappeared. On Feb. 15th the patient complained of pain in the right knee, and towards the anterior superior spine of the ilium. He had an erythematous patch over the head of the fibula, and another upon the iliac spine. Sores soon formed on these two points, and a small central slough separated. After a month these wounds had healed, and towards the last week of March the patient was well enough to try and walk, but complained of tingling pains in his limbs. Soon afterwards the arms gradually became feeble and their movements were limited. The feet then were seized with tingling sensations, and became gradually anæsthetic. The anæsthesia extended to the body. A month later the paralysis had reached its height, and on the 15th of April the patient was in the following state: General movements of the arms were possible, but none of the finer movements could be performed: thus, the patient could not write or hold anything small in his fingers. From time to time painful cramps occurred in the muscles of the arm and forearm. The patient could move the limbs about upon the bed, but was unable to lift them from it. In the legs also there were some muscular tremors. There was weakness in the muscles of the back, especially on the right side. Sensation: The skin of the face, neck, and of the trunk was almost normal. There was anæsthesia of the upper limbs, but not complete. It was at its height in the hands, especially the left. There was complete loss of muscular sense, slight loss of sense of temperature. There was loss of sensation in the lower extremities in their whole extent, more particularly in the sole of the foot. All the tendon reflexes were abolished. The

* *Revue de Médecine*, 1884, p. 334

patient was treated with local friction and douches, and internally by strychnine. The nervous troubles continued at their height for about fifteen days and commenced to improve early in May. Sensation returned, and at the beginning of the month of June the patient was able to write. On the 15th of June he was able to walk. After that time he completely recovered.

Cénas.—Reflex Trophic Changes in both Hands following on Injury to one Ulnar Nerve.*

The patient was a man, aged thirty-nine, who in 1870 had been shot in the right forearm. The bullet penetrated in front of the ulna in its lower fourth, but did not fracture the bone. Some days afterwards a surgeon told him that a nerve had been divided. His attention was drawn towards the three last fingers, which were flexed. He could easily extend them, and could keep them extended, but as soon as he left them alone they immediately became flexed again. At the end of three months the flexion was much more marked, and all movements of extension of the last three fingers had become impossible. The whole of the arm was weak. Six years later the patient for the first time had pain at the inferior angle of the right scapula, and at the same time the hand of the opposite side became affected with trophic changes, the first phalanx of the ring finger being placed in a position of flexion. The skin of the palm of the hand became as it were adherent to the subjacent structures, and all the fingers became gradually flexed. On examination, the patient was found to be strong and healthy. The right hand was flexed slightly, and the wrist could not be fully extended. The three last fingers of the right hand were drawn together and doubled up, the first of the phalanges being flexed upon the metacarpal bone, and drawn towards the ulnar side as in chronic rheumatism. The index finger was not flexed at all. The area of movement of the thumb was slightly limited, but there was no wasting of the muscles of the hand. On the left hand the skin of the palm was dried, and in parts was adherent to the subjacent tissues. The first phalanx of the little finger was strongly flexed, and the third phalanx was extended, the ring finger was thin. The other fingers were of normal size. The ring finger for the last three or four months had

* *Revue de Médecine*, 1884, p. 479.

shown a tendency to become flexed. The muscles of the thenar eminence were a little atrophied, as were also the interossei. There was diminution of sensibility in each hand, though it was rather more marked on the right side.

Blum.—Paralysis of the Musculo-spiral Nerve resulting from a Wound of the Upper Extremity of the Forearm, and followed by Reflex Paralysis of the Muscles supplied by the Median Nerve.—Stretching of the Musculo-spiral and Median Nerves.—Return of Sensation.*

A man, aged twenty-nine, was admitted into the hospital on the 7th of September. On the 9th of July he fell upon a knife and sustained a wound on the upper and outer part of the forearm. Hæmorrhage was arrested, and on the 10th of July the patient went into a hospital. Sensation was diminished in the lower and outer part of the forearm, and was completely abolished on the back of the hand. The movements of flexion and extension were also diminished. On the 17th of July the patient left the hospital. At this time the wound had cicatrized, but he could not follow his occupation on account of the feebleness of the arm, and when he allowed his arm to hang down there was some swelling and a burning sensation. On examination there was found to be a cicatrix situated two centimetres from the bend of the elbow, with its length transverse to the long axis of the forearm. The cicatrix was red, slightly raised, and very sensitive. The forearm was red, as was also the hand, and there was marked muscular wasting. Pronation and supination were natural. The supinator brevis acted normally, the supinator longus contracted more weakly than that of the opposite side. Extension of the hand upon the forearm was very imperfect, as was also that of the fingers upon the metacarpal bones. Flexion and extension of the last two phalanges were normal. The muscles of the palm of the hand were intact. Exploration by the induced current showed some diminution of their contractility. The patient complained of lancinating pains along the forearm. Sensation to touch was normal in all the forearm except at its outer border below. The backs of the thumb and of the index finger, as well as the outer part of the middle finger, were anæsthetic. The patient continued to get worse, and by the 20th of September voluntary and electrical contraction was

* *Archives Générales de Médecine*, 1878, vol. i. p. 32.

completely destroyed in the flexors and extensors. The supinator brevis remained intact, and the long supinator contracted feebly. On the 3rd of October an operation was undertaken, and an incision having been made at the seat of the original injury, the musculo-spiral nerve was exposed close to its division into its terminal branches. It was found to be in a perfectly natural condition, except that it was evidently more vascular than normal, and in this respect contrasted very strongly with the median nerve. Neither the musculo-spiral nor the median had been injured at the time that the wound was inflicted, nor were they compressed by scar-tissue. Both nerve-trunks were stretched. An hour after the operation there was found to be complete return of sensation in all the parts innervated by the radial nerve. On the 4th of October sensation was found to have completely returned in the paralysed fingers, and flexion of the wrist was re-established in part. The muscles of the thenar eminence and the flexors of the hand again acted. The common extensor, the long flexor, and the short extensor did not act, nor did the interossei and the lumbrical muscles. In the beginning of December the patient left the hospital. At this time sensation was natural in the whole extremity, but the extensors of the fingers and of the thumb were still paralysed.

Leyden.—Reflex Paralysis.*

In this case, the patient, on August 14, 1870, sustained a penetrating wound of the right knee-joint. In August 1871, symptoms of myelitis appeared. Soon these were followed by troubles of sensation with feebleness of the limbs, and with slight paralysis of the sphincters. In the right lower extremity there was complete paralysis of all the muscles innervated by the peroneal nerve; in the left leg paralysis of all the muscles of the limb. Tendon reflexes were exaggerated. On the right side a slight improvement followed treatment by galvanism.

Robson.†—Case of Reflex Paralysis.

The patient, a girl, aged fifteen, was quite well up to July 1882, when she fell with a pitcher in her hand and cut her right forearm on its inner and anterior aspect near the middle. The cut, which

* *Klinik. des Rückenmarkskrankheiten*, 1875, p. 232.

† *Lancet*, 1884, vol. i. p. 659.

bled very freely, was about two inches long. It healed slowly, but apparently well. After a few weeks she noticed a little weakness of the right hand, which gradually increased up to April 1883, when she came to the Leeds General Infirmary. At this time there was marked wasting of the ball of the thumb and little finger. The hand was numb, cold, and livid, presenting a contrast to the opposite one, which had a healthy appearance. The faradic current produced feeble contraction of all the muscles except those of the ball of the thumb. The right forearm was rather thinner than the left. There was no loss of sensation when the hand was warm. The scar of the wound, which had healed by granulation, was perceptible in the forearm over the course of the internal cutaneous nerve. Galvanism was ordered to be applied to the affected muscles. In July, the shoulder and upper arm seemed weak, and a wasting of the deltoid was found to have taken place, the posterior scapular muscles also appeared to be impaired in power, and there was a tendency to projection of the scapula, evidently due to weakness of the serratus magnus. Galvanism was ordered to be applied to all the affected parts. This treatment was followed by some return of power in the upper arm and shoulder, and the muscles of the hand apparently increased in volume. The reaction to faradism and galvanism became fairly good in all the muscles except those of the ball of the thumb, where even the strongest current produced no reaction.

Vieusse.—Gradual Paralysis of the parts supplied by the Median Nerve and the Musculo-spiral, following Injury to the Outer Side of the Arm.*

On Sept. 5, 1881, an officer received in a duel a sabre cut on the upper and outer part of the right forearm. The wound healed well, and in three weeks the patient left the hospital apparently convalescent. Up till this time no symptoms indicating injury to any nerve had made their appearance. Two days after his discharge the patient experienced some pain in the forearm, and noticed that the limb was more feeble than natural, and that the hand showed a tendency to flexion. On Oct. 15th ulcers made their appearance on the tips of the thumb, index and middle fingers, the skin of the thenar eminence became purple, hot, and bathed in

* *Bull. et Mém. de la Soc. de Chir.* 1882, vol. viii. p. 650.

sweat. Sensibility was numbed over the lower and outer part of the forearm, and was abolished over the outer part of the back of the hand. Movements of extension were almost absent, and the hand became more and more flexed. Six months after the accident this condition was maintained, but, in addition, there was complete anæsthesia in the area supplied by the median nerve in the hand. The muscles of the forearm contracted, though feebly, to the induced current. The scar of the wound was not tender; there was no pain. On March 20th, the musculo-spiral nerve was stretched, with the result that the anæsthesia of the skin supplied by this nerve disappeared. By April 8th sensation had returned to the area of median distribution, but beyond this, as late as two months after operation, no improvement in muscular power was apparent.

Weir Mitchell.—Progressive Paralysis after Injury to the Elbow.*

A man, aged fifty-one, had his right elbow injured by a bullet, during the American Civil War. In Sept. 1881, he noticed a certain loss of power in the fourth and fifth fingers of the left hand. Two or three weeks later the weakness extended to the other fingers of the left hand. At this time he was compelled to give up work, but the weakness had not grown worse since. "On Sept. 4, 1882, he applied to me. There was no atrophy of the arm, but all the hand muscles are wasted. The hand is dark red and mottled, the skin is smooth and sweats readily. It is also unusually cold to the touch, the sound hand being five degrees warmer than the damaged one. The reflex actions of the hand are markedly increased. Electrically examined, reaction to the faradic current is slightly lessened, but is present in all the muscles. No reaction of degeneration. Under use of tonics and galvanism, with massage, the hand gradually improved, and the pain entirely disappeared."

The above cases will give a better idea of this class of reflex paralysis than any description by myself. It will be seen that some time after an injury there is a gradual loss of power in the muscles supplied by the nerve which innervates the injured area; that this loss of power is sometimes accompanied by muscular twitchings; that paralysis of sensation and trophic lesions are often present; that other nerves tend to become implicated, and

* *American Journal of Medical Sciences*, vol. lxxxvi. p. 17.

that areas in the opposite limb, almost exactly corresponding to the parts which are at first attacked, subsequently become the seat of similar changes in motion, sensation, and nutrition.

Now, if reference be made to the previous chapter on traumatic neuritis, it will be seen that the symptoms of cases of reflex paralysis are precisely those of spreading chronic neuritis, and if cases of the one be compared with those of the other, I think there can be little doubt that in a certain number of cases of reflex paralysis the symptoms are due to an ascending neuritis, with, in some cases at least, a secondary implication of the spinal cord. I have no doubt that, in the large majority of such cases, this is the correct explanation, though I do not think it is so in all, and this pathology receives additional support from the investigations of Treube,* who found that in some cases of reflex paralysis, artificially produced in animals, there was a very distinct inflammation of the nerve-trunks.

I have said that I do not think this pathology holds good in all cases, for I have no doubt that peripheral irritation can *reflexly* cause all these symptoms of muscular spasm and paralysis. I have mentioned such cases in dealing with wounds of cutaneous nerves, cases in which the removal of the cicatrix was followed by immediate restoration of power and loss of pain—a happy result, which could not be so rapidly attained if ascending neuritis was present. Again, cases of paralysis of the optic nerve with loss of vision may undoubtedly be due to the irritation of carious teeth, and paralytic squint may own a similar cause. Thus, Mr. Mummery † describes a case of a class well recognized, in which external strabismus of the left eye was immediately cured by the removal of a carious tooth, and in the same patient, some months later, similar treatment immediately removed ptosis of the eyelid with dilatation of the pupil.

A cause which may act in one part of the nervous system is most likely to be capable of producing similar effects in another part, and, however the result may be produced, I think it must certainly be acknowledged that peripheral irritation is of itself able to cause a reflex paralysis.

The treatment of reflex paralysis in cases where the symptoms do not make their appearance till some time after the accident does not differ from that which I have already described as

* *Archiv. de Neurol.*, 1881, vol. i. p. 278.

† *British Medical Journal*, 1880, vol. ii. p. 18.

applicable to cases of chronic neuritis. Care should always be taken that no local cause of irritation is allowed to remain.

In the first class of cases, where the paralysis occurs immediately upon the receipt of the injury, the prognosis appears to be good. In many cases the paralysis passes away, and apparently all that can be done is to apply the stimulus of galvanism to the affected parts.

CHAPTER XVIII.

**UNUSUAL COMPLICATIONS OF NERVE INJURIES:
EPILEPSY, CHOREA, AND TETANUS.**

AMONGST the more unusual complications of nerve injuries are usually included chorea, epilepsy, and tetanus.

Omitting for the present the consideration of the choreiform movements in stumps, we may say that chorea as a complication of nerve-injuries is very rare indeed. I have seen no such case, and have been unable to find any mention of this condition following the wound of a nerve-trunk, with the exception of one case quoted by Mitchell, under the care of Dr. Packard, where chorea followed a wound of the thumb. It was supposed that a terminal filament of the median had been wounded, and excision of a sensitive point brought about a complete cure after other treatment had failed.

In the absence of other proof, it will thus be seen that the evidence on which the very existence of chorea, as a complication of nerve injury, is founded, is by no means secure. I shall therefore not enter into any theories as to the mode of its causation or the treatment to be adopted.

The occurrence of epilepsy, though rare, rests on a fairly strong evidence as regards its occasional causation by nerve injury.

The peripheral origin of epilepsy, in at any rate some cases, is quite undoubted, and the removal of irritating causes is an essential in the proper treatment of this disease. How such causes act is not completely understood, for the true pathology of epilepsy is yet hidden. One thing, however, is tolerably certain—namely, that they do *not* act by inducing any permanent alteration in the nerve-centres, for the removal of the cause often suffices for the cure.

The occurrence of an epileptic fit is often signalized by an “aura” which is perceived by the patient to ascend from some particular portion of the body with great regularity; it is at

once suggested that the tracks along which the aura travels are the nerves of the part, and the suggestion offers itself that by division of the same the fits may be cured. This line of treatment has indeed been occasionally adopted from very early times, and in some cases with good results. Other surgeons preferred to amputate the finger or other portion from which the aura proceeded, as in the case quoted by Mr. Wardrop.* There seems to be little doubt that peripheral irritation may be a cause of epilepsy, and that a cure may result from local treatment alone.

It thus becomes extremely probable that nerve wounds may occasionally act as the exciting causes of epilepsy, and proof of this is supplied by the following cases :

Létiévant † records the case of a young soldier, aged twenty-two years, who in October 1870 received a gunshot wound of the forearm, injuring the median nerve. The wound remained open for more than a year, and at the end of that time he became subject to epileptic fits, preceded by an aura commencing at the seat of injury. In July 1872, the median nerve was exposed by Dr. Lande, of Bordeaux, and one inch and a quarter was resected. From this time the fits ceased, and at the end of eight months the patient remained cured.

The same author quotes a case by Hamilton, in which a nerve wound was followed by epilepsy. Neurotomy was performed, but the patient died in a fit.

In the *Transactions* of the Medico-Chirurgical Society for 1874 is a case by Mr. Barwell, in which an amputation of the arm, dating back twenty-five years, was followed two years later by a painful stump and epileptiform convulsions. Mr. Barwell opened up the stump, removed a bulbous nerve-end, and stretched the cords of the brachial plexus. During the two months the patient was under notice there was no return of the epilepsy, though up to the time of the operation fits had been of daily occurrence.

We may then safely conclude that the wound of a nerve may induce epilepsy, by providing a source of peripheral irritation similar to that caused by a carious tooth, a foreign body in a wound, a painful blind eye, or any similar condition. The line of treatment to be followed is equally plain, and should consist in removing any source of irritation from the nerve, such as is

* *Medico-Chir. Trans.*, vol. viii.

† *Op. cit.*

supplied by an enlarged and sclerosed termination in a stump, by the pressure of scars or of callus, by chronic neuritis, &c. For the special treatment of each of these conditions, reference may be made to preceding chapters and to that on Nerve-Stretching. In severe cases, where other treatment has failed, excision of a portion of nerve would probably be the right course to follow.

Tetanus.—I suppose there can be no doubt that until quite lately the general opinion as to the causation of tetanus has been that it is the result of a wound of a nerve. It is indeed in deference to this generally accepted opinion that I have not ventured to omit it in considering the complications of nerve-injuries; and having said this, I venture now to express my opinion that injury to a nerve is in no way a cause of tetanus, and that in fact they have nothing to do with each other in the relations of cause and effect. But under any circumstances this is scarcely the place to enter into a lengthy discussion on tetanus; so I do not propose to go beyond a brief consideration of what appears to have been the prevalent opinion on this subject, and my reasons for disagreeing with the same.

It is evident that many errors have arisen because we have been far too prone to accept on insufficient evidence the statements made of the neurotic origin of tetanus, the facts which are supposed to support this theory, and the deductions drawn from them.

I shall endeavour to prove that the widely accepted doctrine of nerve injury being the primary cause of tetanus is quite untenable, and not sufficiently supported by facts.

With regard to this doctrine, however, I would remark that it is extremely difficult to meet with any very definite statements as to the conditions which are supposed to be set up by or in the wounded nerve, but I think that the various theories may fairly be stated as follows:

Tetanus is caused—

(a) By simple injury of a nerve, the irritation arising from which causes excessive reflex action over the whole body.

(b) By inflammation of a peripheral nerve, excited either by direct injury or by spread of inflammation from surrounding tissues.

(c) By injury to a nerve, followed by inflammation, which spreads to the spinal cord.

Now, if we look for the evidence which supports this pathology,

we shall find but very little reward for our pains. The whole superstructure has been built on so shallow a foundation that we can only be astonished it has stood so long.

The first theory—that a simple nerve wound is of itself sufficient to set up tetanus—is manifestly absurd. For in every incised wound, in every amputation, either some nerve filaments or trunks, or both, are certain to be wounded; nevertheless, the accidental discovery of an injured nerve has by several authors been gravely recorded as the cause of death in cases of this disease. If, however, it be urged that it is only in cases where the larger trunks are implicated that tetanus supervenes, I would answer that such a statement cannot be supported by facts. Thus, Weir Mitchell* says that he has seen over 200 cases of gunshot wounds of large nerve-trunks without a single case of tetanus; and in the more rare instances of wounds of nerve-trunks, lacerated or otherwise, such as are met with in civil practice, tetanus is no more frequently seen than in injuries which do not involve such structures.

The second theory—namely, that tetanus results from inflammation of a nerve—is merely supported by such vague statements as, “the nerve-trunks appeared more vascular than natural,” “the nerves were redder than normal,” “the nerves were distinctly congested,” and similar loose phrases. Nevertheless, out of more than 200 cases which I have collected, even such appearances as these were noticed in only 9 per cent.; and of late years, when investigations have been more accurately conducted, the number of such cases has much diminished. Relative to this point, I will venture to quote a very significant passage from an article by Dr. J. H. Laurie,† in which he says: “In vol. iv. p. 90, of the *Glasgow Medical Journal*, the results of some post-mortem examinations were published by Dr. Perry, with the view of showing that inflammation of the nerves at the seat of injury, and of the nervous trunks connected with it, was probably one of the exciting causes of tetanus. It so happens, however, that I conducted some of these post-mortem examinations for Dr. Perry, and subsequent investigations have shown me that, as far as morbid appearances are recognizable to the eye and the methods of examination then in use, the nerves of a tetanic

* *Injuries of Nerves*, 1873.

† *British Medical Journal*, Nov. 1, 1853.

injury differ in no appreciable respect from those in which that disease has not supervened." Yet there can be but little doubt that statements such as the one here alluded to have laid the foundations for much of the pathology of tetanus.

And what is said of these examinations may, I believe, be said of all. No typical inflammation of a nerve is constantly present in tetanus. On the other hand, I would venture to assert most confidently, that if so-called "inflamed" or "congested" nerves were looked for in patients who die with open wounds from other diseases, they would just as frequently be found as in tetanus. In most cases of compound fracture, of lacerated wounds of the extremities, &c., the nerves participate in the inflammatory changes common to the other tissues—to, at any rate, a sufficient extent to show a marked redness to the naked eye; yet this reddening appears to be mainly confined to the sheath, and not to affect the more important parts of the nerve-trunk—namely, the fibres. Such appearances, therefore, cannot be held to account satisfactorily for the disease in question.

Again, if inflammation of a nerve really be present, we surely should not need to wait for a post-mortem examination to establish the diagnosis. The symptoms of acute neuritis are extremely severe; the pain and tenderness is unbearable, the constitutional condition seriously disturbed, and the inflamed nerve can be felt enlarged, hardened, and tender for some distance along its course. Where are these symptoms in tetanus? It is certain that the wounds which result in tetanus are not painful above all others; but looking at this part of the argument from another point of view, we are tempted to ask—Does tetanus supervene where neuritis is undoubtedly present? And the only answer is a direct negative.

Moreover, the practice now common in surgery of inserting sutures into divided nerves would surely ere now have resulted in tetanus had nerve section, or inflammation, or the presence of foreign bodies been a frequent cause of this disease; yet, as far as I am aware, no such accident has been recorded.

The third theory, that tetanus results from an inflammation spreading along a wounded nerve, and so reaching the spinal cord, is so entirely hypothetical and unsupported by any evidence, that, for the present, it requires no further notice.

Another argument which is constantly adduced in favour of the neurotic origin of tetanus is that cures are said to have followed

section of the injured nerve. But here also a great deal of theory has been founded on very little fact. The following are the only cases I have been able to find recorded. It is quite possible that they may be more numerous, but a somewhat lengthy search has convinced me that the total number must really be very small.

Larrey,* in two cases of tetanus, divided the tissues forming the floor of very painful wounds, and the tetanic symptoms rapidly disappeared. The object of the operation was to divide some wounded nerves which he believed were keeping up the irritation.

Dr. Murray † records a case in which section of the posterior tibial nerve for tetanus following on a wound of the foot resulted in recovery.

Samuel Wood ‡ divided the saphenous nerve in a case of tetanus of a very mild nature, which resulted from a compound fracture of the leg. The patient recovered.

Drs. Basi and Marinelli § divided the musculo-cutaneous nerve for tetanus following a gunshot wound of the arm. The patient recovered.

Mr. F. S. Edwards || records an instance of recovery following on the division of the short saphenous nerve, the original injury being a dirty lacerated wound of the heel, followed by sloughing.

Sir J. Fayrer ¶ details a case of a lacerated wound of the hand, followed by an apparently slight attack of tetanus on the fourth day from the injury. Four days later the median nerve was divided, and the patient recovered.

The same surgeon, at the discussion which followed on Dr. Coats' paper on tetanus,** said that he had seen three cases in which tetanus had been arrested by section of the median nerve. I have not, however, found any details of others than the one first described.

It thus appears that but nine cases of recovery can be said to have followed on nerve section; but in some of these I believe it would be more accurate to say that it had occurred in spite of the neurotomy. Looking at the cases seriatim, we shall, I think,

* *Mémoires de Chirurgie Militaire*, vol. iii.

† *Medical Gazette*, Feb. 9, 1883.

‡ *British Medical Journal*, July 4, 1863.

§ *Lancet*, May 1873.

|| *St. Bartholomew's Hospital Reports*, vol. xvii.

¶ *British Medical Journal*, Oct. 10, 1863.

** *Med.-Chir. Soc. Trans.*, vol. ii.

come to the conclusion that adequate proof is wanting as to the efficacy of the treatment advocated.

In each of Larrey's patients it is very doubtful if any nerves at all were divided. Very likely they were; but the author's chief reason for believing so was the fact that the wounds were very painful, and traversed the course of certain nerve-trunks.

Dr. Murray's case, though so frequently quoted, is quite unlike any other example of tetanus with which I am acquainted. The patient, a lad of fifteen, ran a nail into his foot, and, after keeping a night-watch on board ship, had great stiffness of the jaws and neck next morning. Within a few hours, and without waiting for any further symptoms, the posterior tibial nerve was divided, with the result that the patient was at once relieved from all symptoms. That this was not a case of tetanus at all, but only of trismus, there can, I think, be no doubt. To Dr. Murray's statement, that the nerve was "twice as large as natural, but of normal colour," I should attach no importance; for I am well aware that nerves exposed during life do really appear larger than in the dissecting-room.

In Mr. Wood's case the wound of the nerve was indicated by pain and tenderness in its course, and the patient certainly appears to have derived benefit from the operation.

In the case recorded by Mr. Edwards the tetanus was more marked and the spasms more violent twenty-four hours after the operation than previously, and recovery was not completed for a fortnight. The patient was, in addition, treated by frequent doses of chloral and a Chapman's spinal ice-bag. Under these circumstances I should be very unwilling to accept this as a case of recovery from nerve section; it appears most likely that this part of the treatment had no hand in bringing about such a fortunate result.

Much the same remarks apply to the case detailed by Sir J. Fayrer. In addition to the division of the median nerve several splinters of wood were removed from the wound, and the spasms continued some days after the operation. Large doses of opium, Indian hemp, and chloroform were also administered. Who, then, shall say to which of these various remedies belongs the merit of the result? The two other cases by the same author do not admit of criticism, for there are no data on which to work.

The patient of Drs. Basi and Marinelli suffered from tetanus for

three days after the neurotomy, but it is not stated whether any other treatment was employed.

I would therefore submit that the recorded cases of tetanus treated by neurotomy are far too few and too doubtful to afford any material support to, and much less to prove, the neurotic origin of this malady. As is so often the case, the constant reiteration of a single case has led to the belief that a cure has been far more frequently the sequel of neurotomy than really appears to be the fact; and I venture to think that the argument that such a result follows neurotomy, cannot fairly be held up as proof of the theory that tetanus results from neuritis.

With regard to the more recent treatment by nerve-stretching, I may say that I have not seen the accounts of a single case in which cure could certainly be attributed to this procedure, though I am inclined to believe, on the other hand, that it has in one or two cases accelerated a fatal ending. To this subject I shall again refer.

But if the disease really were of peripheral origin, the division of the nerve-trunks ought to provide a certain means of cure. Not only, however, is this not the case, but even such complete isolation from the injured part as is afforded by amputation does not give much more satisfactory results. I am well aware that it has been argued that when neurotomy fails it is because the treatment has been too long postponed; because the disease has been "generalized," and is no longer local. I can only confess my inability to understand such logic until it can be clearly shown that it is possible for such excessive and widely diffused reflex action as is present in tetanus to remain, when the exciting cause has been removed. The theory which assumes such a pathology is entirely without a physiological basis.

Such, then, is a very brief sketch of the chief *facts* brought forward to prove the neurotic origin of the disease; and in continuation of the arguments I have already brought against their acceptance as sufficient proof, I shall turn very shortly to some further objections of a theoretical nature.

Were it true that tetanus is due to peripheral irritation, we should certainly expect to find it caused by many other varieties of irritants; for cases are occasionally met with of wounds and scars so hyperæsthetic that the slightest touch causes extreme pain; and, more especially when the bulbous end of a previously divided nerve is exposed, even epileptiform fits may result from an external

irritant. Again, if peripheral irritation and consequent excessive reflex action could account for tetanus, surely the first symptoms ought to be noticed in the injured part. If the leg were damaged, it ought most certainly, according to all physiological laws, to be the first part affected by spasms; yet, as a matter of fact, the muscles of the neck and jaws are almost invariably the earliest to become contracted.

As regards the supposition that tetanus may be due to inflammation spreading along the course of a nerve-trunk and thus reaching the cord, I have already stated that there are no facts to support such a theory; and it is notable that the only pathological lesions which have been described were almost limited to the medulla oblongata and pons, whereas, if the above be true, such changes ought to be most marked *in that part of the cord from which the wounded limb obtains its supply of nerves.*

But if tetanus is not due to local irritation or to implication of nerves, to what cause is it to be attributed? It seems to me that, even without experimental proof, there are many clinical facts which render it extremely probable that the disease is due to some constitutional condition, some variety of blood-poisoning; and, without attempting to draw any conclusions, I shall venture to indicate such points as appear to be favourable to this theory. Many of them, no doubt, have been noted by other writers already. First, the occasional but undoubted idiopathic origin of this disease seems to show that local injuries are not essential for its production. Next, the remarkable fact of its extreme prevalence in certain climates, and especially in certain localities, would lead to the conclusion that it is independent of the injury of any special tissue, whilst its endemic occurrence puts it partly on a level with such undoubtedly constitutional states as malaria, ague, &c.

The fact that it attacks by preference the coloured rather than the European races points in the same direction. The effects of temperature, and more especially of exposure to cold and wet, are scarcely conditions which could exercise much influence in the production of a disease of local origin, whilst it is quite possible that such might be favourable to the absorption or formation of some local materies morbi.

I do not think that enough attention has been paid to the wound, for in a very large number of recorded cases it has been found in a very unhealthy state, either inflamed, sloughing, gan-

grenous, or containing retained pus. Thus in 143 cases taken in succession from the medical journals in which the state of the wound was mentioned, in 68 it was in one of the above conditions. I am quite aware that many observers have stated that the condition of the wound bears no relation to the onset of tetanus, but I can scarcely believe that the high proportion of unhealthy wounds above recorded is a mere coincidence, whilst the cases I have seen myself tend entirely to corroborate such an opinion.

And while speaking of the condition of the wound, it may be noted that much stress has been laid by some observers on the occasional presence of foreign bodies in the injured part. These have generally been considered as likely to cause tetanus by exciting irritation and inflammation of the contiguous nerves; but I would suggest that any influence they may exercise is more likely due to the fact that wounds in which foreign bodies are imbedded are rarely in a healthy state.

Another argument in favour of the constitutional nature of tetanus is the fact that it occasionally appears to occur in epidemics, and under circumstances similar to those which we know to be favourable to the development of some of the other forms of blood-poisoning—namely, overcrowding, bad ventilation, and other varieties of faulty hygiene. Thus, at one time in the American war over fifty cases occurred in rapid succession in the hospitals at Washington and Fredericksburg. One operator in Germany lost seven patients from this disease after ovariectomy, and I have recently been told of three patients all dying of tetanus after similar operations in the same ward. But of all the varieties of tetanus, that which brings the strongest evidence to bear on the constitutional origin of the malady is “tetanus neonatorum.” First, it is markedly endemic; secondly, it attacks by preference the children of coloured people; thirdly, the umbilical cord is frequently in a sloughy or otherwise unhealthy condition; and lastly, it has been shown most clearly that it is almost entirely dependent upon bad hygienic conditions. The influence of this latter has been so fully demonstrated by various authors, more especially by Dr. Joseph Clarke of Dublin, that it is unnecessary for me to insist upon it any further; while the absence of all spinal nerves from the umbilical cord itself renders it impossible that nerve lesion should play any part in the causation of this disease.

Lastly, the high temperature occasionally noted lends aid to the theory of the presence of some morbid material in the body; for

the fever is certainly not the result of the spasms, or it would be present, not only in a larger number of cases of tetanus, but also in uræmic convulsions, puerperal eclampsia, and other similar diseases.

As regards the post-mortem appearances of tetanus, I think there can be no doubt that no one lesion is constantly present in all cases. Drs. Dickinson, Lockhart Clarke, and others, have described and figured most extensive lesions of the spinal cord, and it is the very extent of the same that makes it almost impossible to accept them as pathognomonic of tetanus. The damage inflicted upon the cord, according to these authors, is so extensive, that it is certain that had the patient survived considerable paralysis must have resulted; yet in those patients who have been fortunate enough to recover no paralysis has ever been noticed.

Other observers, and more particularly Dr. Coats, have described peri-vascular accumulation of leucocytes and atrophy of the nerve-cells of the cord. In all the cases I have examined the spinal cord has been entirely and typically normal. In one case the motor parts of the brain were congested and softened. It is therefore a fair conclusion to draw that acute traumatic tetanus *can* prove rapidly fatal without affecting the nervous centres to any obvious extent. Now such post-mortem results are quite compatible with the theory that tetanus is due to some poisonous material circulating in the blood. It requires no great stretch of the imagination to suppose that such a poison might, like strychnia, have a selective action on the nervous centres, or on particular parts of the same. It is also a perfectly fair suggestion that, as in the case of the drug just mentioned, the poison might act in a purely functional manner, or else might induce changes in the tissues, either by its direct action upon them, or else by the excessive functional excitement induced. The suggestion which has been made (and which is a sort of compromise with the neurotic theory) that the poison may be absorbed along the course of or by the nerve-trunk, is negatived by the facts, that the first symptoms do not point to an early affection of that part of the cord from which the nerve springs, and that there is no correlation between the part injured and the seat of any post-mortem changes when such are apparent.

One more suggestion. The similarity between tetanus and hydrophobia has already been pointed out by more than one author. I have drawn attention to the frequently unhealthy

condition of the wound, and the fact that it may, at the time of the onset of tetanus, either be healthy or healed, appears at first sight to militate against the suggestion that some morbid process is taking place in it. It is, however, quite possible that, as in hydrophobia, a varying length of incubative period may elapse between the inoculation and the commencement of the symptoms, and an explanation is thus afforded of the failure which generally follows amputation. The poison has been discharged into the system at some previous period, and removal of the seat of inoculation comes as a rule too late. But seeing that as yet all this is mere surmise, the practice of thoroughly attending to the state of the wound is deserving of every recommendation.

Although, however, there is thus much clinical evidence in support of the toxic origin of tetanus, the proof of such a theory must be afforded by experimental research. And of late years this has been provided beyond the possibility of a doubt by Carl and Rattone,* and by Nicolaer.†

The following is a brief summary of the paper by the first-named authors :—

On Nov. 29, 1883, a man was admitted into hospital with typical tetanus, which was attributed to an inflamed pustulating acne spot. The patient died the following day. Two hours after death, the pustule with the circumjacent tissue was excised, and from it a cultivation fluid was formed, and with this fluid experiments were made.

1. Twelve rabbits were directly injected.
2. Four rabbits were injected with material from tetanized rabbits.
3. Eight rabbits were injected with septic pus and decomposed blood.

The results were as follow :

1. Injection with material from patient's wound. During the first two days the rabbits showed no signs of infection. On the third or fourth day they became ill, and refused food. This condition was accompanied by tremors of the extremities. On the fifth day there were contractions of the muscles of the neck, the head was drawn back, and opisthotonos ensued with rise of

* *Gaz. Med. Ital. Prov. Venete*, Nov. 15, 1884; and *London Medical Record*, Jan. 16, 1885.

† *Deutsche Med. Wochens.*, Dec. 25, 1884; and *London Medical Record*, April 15, 1885.

temperature and hurried respiration. In this state, any sudden noise or disturbance caused an increase of the contractions. The animals died after three or four days' illness.

2. Rabbits injected with material from tetanized rabbits. Two rabbits were injected with a maceration, and tetanus followed. Two others were injected with blood, with a negative result.

3. Rabbits injected with septic substances. These animals showed none of the signs of tetanus.

Further experiments by Nicolaer tend to show that the materies morbi may depend upon the presence of a certain organism found only in certain soils. He found that he could produce a peculiar and unvarying succession of symptoms by inoculating mice and rabbits with small pellets of earth, taken from particular situations, which he found by microscopic examination to contain a fine thread-like bacillus. The course of the symptoms was in all cases the same. An incubation period of one and a half to two and a half days in mice, and four to five days in rabbits, was followed by stiffness, attacking first one extremity, then another, beginning with the one nearest to the site of the inoculation and spreading over the body until opisthotonos was induced. Death occurred in twenty-four hours in mice, after about two days in rabbits. The same symptoms, only more energetic, ensued upon inoculation with pus taken from an inoculated animal, or with any portion of the animal's body, and it could also be induced by the bacillus after cultivation in suitable fluids.

Further experiments by Rosenbach,* Ferrari,† Ballance,‡ Shakespeare,§ Nocard,|| Hochsinger,¶ and Beumer,** have further demonstrated the inoculability of tetanus, and the presence of a definite organism; and as tetanus can therefore be no longer considered as a complication of nerve-injury, I do not propose to consider further its symptoms or treatment. An excellent review of the more recent investigations into its pathology has been published in the *Lancet*, Feb. 4, 1888, by Mr. William Anderson, and to this I am indebted for several of the above references.

* *Central. für Chir.*, 1886.

† *La Semaine Médicale*, April 13, 1887.

‡ *Lancet*, Feb. 4, 1888.

§ *Brit. Méd. Jour.*, Oct. 1887, vol. ii. p. 713.

|| *Bulletin Médical*, Dec. 14, quoted by Anderson.

¶ *Central. für Bakteriologie*, 1887, Band ii.

** *Ibid.*

CHAPTER XIX.

**GENERAL TREATMENT OF THE VARIOUS MORBID
CONDITIONS WHICH ACCOMPANY INJURIES
OF NERVES.**

IN addition to the reunion of the divided nerves there are many symptoms and various conditions of the parts cut off from their nerve-supply which require treatment. Some of the first of these in importance are caused by the injury inflicted on the motor fibres. The loss of motion which is the inevitable result of section of a motor nerve, and which at first is simply due to separation of the muscles from the nervous centres, is very rapidly followed by a wasting and degeneration of the muscle-fibre such as I have already described. This condition is due to the want of proper innervation, and is not simply the result of disuse. Nevertheless, there can be but little doubt that these changes in the muscles are delayed and diminished by any method which induces artificial contraction, and in cases where the nerve-ends have been placed in the position most favourable for union, and we are waiting for regeneration of the nerve-fibres, much good may be done by keeping the muscles in as good a state as possible in the meantime. With this intent the employment of electricity is most valuable.

I have, while writing of the degenerative changes in muscles, already stated that a muscle cut off from its centres of nerve-nutrition rapidly loses its reaction to the faradic current, but retains its galvanic irritability for a much longer period, the latter only being lost when its contractile tissue itself is changed in character. In selecting an agent to take the place of the natural nerve-current, we should certainly be guided in our choice by a consideration of this fact, and I am strongly disposed to consider that the galvanic current is much more useful than the faradic in maintaining a normal condition of the muscle, and in favouring a return to such a state after the re-establishment of the continuity of the nerve.

In the employment of either of these methods, one of the first considerations is the frequency with which the current should be applied. I have no doubt that good may be done by the use of the same only once or twice a week, but in severe cases it is certainly advisable to increase the number of sittings to every alternate day at least, or indeed to every day of the week. The strength of the current must be regulated by the condition of the muscles, such a number of cells being used as are sufficient to induce contraction; should the case proceed favourably the number required will steadily diminish.

In patients in whom a long time has elapsed since the injury, and in whom the muscles have been long paralysed, it is often necessary to employ the current for some time before any reaction is observed; in such cases it is useful to thoroughly soak the arm in warm salt water for some time before the electrodes are applied to the skin, and even if no effect is produced at the first sitting, a little perseverance will often be rewarded by a steady and gradual improvement.

The length of time required for each application of the current varies from ten minutes to half an hour or more, the greater the amount of the paralysis, and the more muscles affected the longer should be the sitting. Each muscle should be galvanized in turn, and the greater the loss of power the more care should be expended. Some precaution is necessary in order to avoid overtiring the degenerate tissue, so that when towards the end of a long sitting a muscle, previously paralysed, begins to react to the stimulus, we should very readily be content with merely an indication of such returning power, feeling certain that at the next application of the current much improvement will be recorded. The pain sometimes caused by this treatment places another limit on the time of each sitting; it, however, as a rule rapidly diminishes, and does not form any serious obstacle.

In addition to the use of electricity, much good may be effected by constant rubbing and kneading of the paralysed muscles. This probably acts by tending to induce contraction of the muscle-fibres, and possibly by improving the circulation; it tends also to prevent the atrophic and degenerative changes which are so prone to occur. Again, where the muscle is shortened, hard, and contracted, these conditions rapidly yield to careful massage.

Treatment such as this may be applied daily, and in order that full benefit may be derived the services of a professional "rubber" should be employed. At the first sitting but little good can be

expected to be evident, especially when atrophic changes have been long in progress; but even at first, under skilful handling, a marked temporary improvement may be seen in the condition of the skin, which, being blue and cold, soon becomes of a more natural hue and temperature, and finally, at the end of the day's treatment, warm and moist.

At first, the skin should be gently pinched and moved on the subjacent fascia over the whole of the paralysed part, the muscles are then pinched, rolled, and kneaded, more especially in a direction transverse to their long axis, the amount of force used being gradually augmented during the sitting and on each successive day. Finally, all joints in anywise stiffened, either by changes in themselves or else by contraction of surrounding muscles, should be similarly kneaded, and then gently but forcibly moved in various directions. The amount of good to be obtained by this method of treatment is almost incalculable, and cold, atrophied, and deformed limbs rapidly assume a more normal condition, at the same time that many painful states pass away.

I have already alluded to the deformities which may result from the atrophy and paralysis of the muscles as being in some cases due to a contraction of the degenerated muscles themselves, in others to an undue action of their opponents. The latter conditions can be most usefully benefited by such treatment as I have already described, and by care, on the part of the patient, to limit the tendency to displacement. In the former circumstances, the shrinking of the muscle will often yield to massage and passive exercise, but when the contraction results in a distortion which cannot be overcome, and which is either painful or inconvenient, much good may sometimes be done by the division of the tendons which keep up the deformity, and a gradual replacement by means of orthopædic apparatus. Either paralytic cases of deformity or in those due to spasmodic contraction of the muscles but little good can be expected from galvanism of the opponents, and this treatment will almost invariably result in disappointment. The latter condition as a result of nerve wound is but seldom of long duration, and as it is generally due to irritation rather than to division of a nerve, the removal of the cause will generally suffice for the cure. While speaking of this, I may mention that Mitchell has found great good to result from the injection of atropia into the muscle itself, in patients in whom the contraction was due to rheumatic changes affecting the nerves.

Treatment of Anæsthesia.—The treatment of the anæsthetic conditions apart from the injury of the nerve itself, has appeared to me to yield most unsatisfactory results. I am not at all sure that I have ever seen any real good result from galvanism, faradization, counter-irritation, or any other method of treatment; at the same time any of the above may be used so long as faith is not put in them to the exclusion of the necessary means for procuring reunion of the nerve-trunk.

Treatment of Pain.—The treatment of the various kinds of pain which are so frequent after nerve-injuries, is certainly of the greatest importance. Perhaps one of the first facts most necessary to recall to mind is, that the pain which is the most acute is the most likely to be transient; that if a patient suffers, for example, from “acute neuritis” with its consequent agony, the symptoms may be combated with a tolerably firm assurance that, provided pain can be temporarily allayed, the exciting cause will gradually pass away. What then should be the course of treatment to be pursued in “acute neuritis”? Briefly, an antiphlogistic one. The part should be kept at absolute rest, leeches or bleeding-cups placed along the course of the inflamed nerve, and morphia injected to give ease to the constant pain and restlessness. If cold be grateful to the patient, ice-bags may be placed along the limb; or if heat should afford greater relief, poultices or hot fomentations should be used. In addition to the above, the burning pain or “causalgia” is more particularly relieved by the application of cold water, and keeping the part constantly moist; while in many cases, blistering, or counter-irritation of an extensive skin surface is of great benefit. Where they can be borne, galvanism and massage may be found most useful, and in all cases the affected limb should be carefully protected from cold. Any constitutional state requiring treatment should be attended to, and tonics, good food, and favourable hygienic conditions are all factors in bringing about a cure, not only of the pain, but also of the paralysis of the affected muscles.

When pain has become chronic and is constantly present, when the nerve-trunks become painful, enlarged and tender—when, in fact, symptoms indicative of chronic neuritis supervene, and are not amenable to the different methods of treatment already described—the question comes before us whether any good can be expected from operative procedures. This question is oftentimes an urgent one, as the patient is frequently willing to submit

to almost any operation which holds out any prospect of relief from an agony which may be unendurable. For in chronic neuritis, the constant wearing pain produces an abnormally irritable state of the cerebral centres, the health breaks down, and the man becomes incapacitated for work of any kind. Several very remarkable instances of such cases are recorded by Mitchell, and, in some, the patients have cheerfully submitted even to amputation of the limb, in the hope, which was not always realized, of obtaining relief.

Up till very recent years, the chief resource of surgery in such cases of chronic pain has lain in division or excision of a portion of the nerve-trunk which has been damaged, but the results obtained have frequently been so unsatisfactory that amputation has subsequently been resorted to, in at any rate some instances.

With regard to the operation of neurotomy, it is advisable to consider what are the exact conditions of the nerve-trunk which give rise to the neuralgic symptoms, for these, as I have already pointed out, are mostly due to a chronic inflammation with induration slowly spreading up the nerve, and affecting different trunks in its progress; adhesions are formed with the surrounding tissues, the nerve-fibres are compressed and irritated by the inflammatory growth, and are maintained in such a permanently irritable state that the slightest stimulus gives rise to pain.

This condition is more likely to follow on such injuries as bruises, torn and lacerated wounds, gunshot injuries and the like, rather than on simple nerve section; it may also be the sequel of "acute neuritis." If such cases come under notice sufficiently early, and are treated by the methods already described, it will seldom be necessary to proceed to further measures to ensure relief. But when the neuritis has been long established, and in spite of all treatment continues to spread towards the centres, it assumes a condition of prime importance, and calls for such operative procedures as may be available.

But the operation of neurotomy must be considered as inflicting a very severe injury on a limb, and one which should, if possible, be avoided; a point the importance of which it is quite unnecessary to press, when we consider the many troubles that are in store for a part deprived of its nerve supply.

But does an operation so severe invariably produce a satisfactory result? To this we must give a decidedly negative reply, and must then seek the cause of failure. This will generally be

found in the fact that the inflammatory changes have already spread beyond that part of the nerve which has been divided or resected. If, then, an operation be decided upon, it is most necessary that the utmost care should be expended upon a very careful examination of the nerve-trunk, with a view of ascertaining to what height the inflammatory or sclerotic changes have spread. The tenderness and thickening afford the most reliable evidence on which to proceed, it being always remembered that the higher up the section is made the more likely are we to meet with healthy fibres; for the neuritis often spreads much higher than appears from a casual observation. It must, then, be clearly understood that the most frequent cause of failure of neurotomy or neurectomy, and of the continuance and recurrence of the pain, is not the reunion of the divided ends, but the continuation of morbid processes in that part of the nerve which is in connection with the nerve-centres. It would, however, be wrong to suppose that this is invariably the case, and it is probable that in some few instances reunion has something to do with causing a return of the neuralgic conditions when the pain is referred to the periphery. In order to prevent such a possible contingency, it is advisable to remove two or three inches of the nerve, while some authors have recommended in addition that the upper end should be doubled back upon itself so as to turn the cut surface upwards; the lower end may be treated in the same way. Supposing, however, that, as is sometimes the case, the painful condition recurs, the question then arises as to the advisability of performing amputation, provided always that the neuralgia is of sufficient intensity to elicit such a request from the patient. It is, however, difficult to conceive how an amputation could in any way benefit the sufferer to a greater extent than might be obtained by a simple section of the nerves at such a point as they would be cut in the operation, and as several failures have been recorded, the treatment is not one I should care to recommend as a curative measure. It may, perhaps, be adopted in order to relieve the patient of a useless and cumbrous appendage, though this is, of course, entirely a question for his own consideration.

We must then own that the results of neurotomy and neurectomy are not altogether satisfactory, and it remains to be considered whether any treatment can be adopted which, while more efficacious, is free from the drawback of inflicting a permanent injury on the parts supplied by the damaged nerve.

Until the most recent years we might have looked in vain for any suggestions as to additional operative procedures, but of late the results obtained by nerve-stretching have been so successful in cases similar to those which are under notice, that I should in all cases practise this operation before proceeding to neurotomy or neurectomy.

As I shall again return to the subject of nerve-stretching, I shall not, at present, enter into further details.

CHAPTER XX.

NEUROTOMY AND NEURECTOMY.

By the term "Neurotomy" is implied division of a nerve, by "Neurectomy" excision of a portion of its length.

In the case of neurotomy, the operation may either be performed by the subcutaneous method or by first exposing the nerve by means of an incision through the soft tissues.

Supposing that it is necessary to expose the nerve for the performance of either neurotomy or neurectomy, the incision in the skin should, as a rule, run parallel to the course of the nerve-trunk, though in certain cases this rule may be departed from. Such operations are much facilitated in the case of the extremities by a previous exsanguination of the limb by the use of an Esmarch's bandage.

As in the case of ligature of vessels, there are certain "seats of election" for the exposure of the chief nerves, and it is at such places that they can be exposed with the least amount of damage to the surrounding parts.

The following is a brief description of the operative procedures by which those nerves which are the most likely to call for surgical interference may be exposed:—

The Supra-orbital Nerve.—The supra-orbital notch can always be readily felt. The nerve, after emerging from the orbit at the notch, passes directly upwards towards the scalp. It may be exposed by an incision carried through the skin, fascia, and orbicularis muscle. In this case, as in that of the supra-trochlear, the usual rule of making the incision parallel to the course of the nerve may be departed from, and the skin may be incised in a line parallel to the eyebrow and just below it, the reason being that transverse scars in this situation are less perceptible than are longitudinal ones.

The Supra-trochlear Nerve.—The pulley for the superior oblique muscle may usually be readily felt at the inner angle of

the orbit; the supra-trochlear nerve emerges immediately above it, and may be reached by an incision similar to that required for exposure of the supra-orbital nerve, but a little more to the inner side of the orbit.

The Infra-orbital Nerve.—The infra-orbital canal, from which the nerve emerges, is in a line drawn from the supra-orbital notch to the first bicuspid of the same side. The nerve may be exposed by an incision in this line commencing below the prominent lower edge of the orbit; it is situated at a greater depth than might be imagined.

In exposing any of the branches of the fifth nerve upon the face, there is often troublesome bleeding from the vessels which accompany them. After ligaturing such arteries as bleed most readily, the remaining hæmorrhage is best arrested by steady pressure with dry lint or sponge for several minutes. In this way a much more satisfactory view of the nerve can be obtained than if blood is continually welling up and filling the wound.

The Inferior Dental Nerve.—Numerous operations have been devised in order to expose this nerve. The following are the chief:

First. A curved incision is made with the concavity forward immediately behind the angle of the jaw. The masseter muscle is exposed and reflected, and the bone is trephined opposite the dental foramen—*i.e.*, at a point about one inch and a quarter from the lower margin of the jaw. The nerve is seen passing in a direction from above downwards across the centre of the trephine hole.

Second. An incision is made parallel to the posterior edge of the ramus of the jaw. The bone is exposed, the internal pterygoid is separated by the finger, and the nerve reached just where it enters the dental canal. It can now be drawn into view with either a blunt hook or an aneurysm needle. This operation is recommended by Chauvel.

Third. An incision is made parallel to the anterior margin of the ramus. All the tissues forming the thickness of the cheek, with the exception of the mucous membrane, are divided, the internal pterygoid muscle is separated with the finger, and the nerve exposed as in the previous operation.

Fourth. The cheek is incised immediately in front of the condyloid process, at the level of the lobe of the ear, and the nerve is sought for in the sigmoid notch.

Fifth. The angle of the jaw may be removed by cutting forceps

after exposure by means of an incision similar to that described in the first method of operating.

Sixth. The lower jaw may be disarticulated after the joint has been exposed by an incision behind it, and the nerve sought for close to its emergence from the foramen ovale. (Recommended by Crédé.)*

Seventh. The nerve may be reached, without any skin incision, through the mouth. The operation is performed as follows:—

The mouth being opened as widely as possible with a gag placed on the side opposite to that on which the nerve is to be exposed, an incision is carried along the anterior border of the ramus of the lower jaw, extending from the last upper molar to the corresponding tooth in the inferior maxilla; the mucous membrane being divided, the finger can be inserted between the internal pterygoid muscle and the ramus of the jaw. The muscle being pushed inwards, the sharp spike of bone at the orifice of the inferior dental canal will then be the best guide to the nerve, which may be caught up as it enters the foramen by the backward sweep of a sharply curved aneurysm needle. Care is requisite to avoid mistaking the internal lateral ligament of the jaw for the nerve. (Recommended by Paravicini, Létievant, and Walsham.)

Eighth. Dr. Sonnenberg has instituted a new operation for an excision of a portion of the inferior dental nerve. The head being held strongly backwards, an incision is begun one centimetre and a half in front of the angle of the jaw and continued along the body of the lower jaw for three to four centimetres as far as the facial artery, an incision which corresponds roughly to the insertion of the masseter muscle. The inner surface of the lower jawbone is next exposed, and the internal pterygoid is separated from the bone. The nerve may now be felt, and is easily drawn to the surface with a blunt hook. The advantages enumerated by the author are—1. The wound is small. 2. The operation is easily performed. 3. The bleeding is insignificant. 4. The capsule of the submaxillary gland is left intact, and so no burrowing can take place. 5. The nerve is easily found. 6. A large piece can be removed. 7. The wound is favourably situate for healing, and the scar is small and in an unobjectionable place.†

In estimating the value of these several operations, there is, I think, little difficulty in putting some of them aside at once.

* *Berlin. Klin. Woch.*, April 1880.

† *Ibid.*, Oct. 16, 1883.

Those which I have numbered as the fourth, fifth, and sixth, have nothing to recommend them in my opinion, for they either tend to disfigure the face or are unnecessarily severe. That operation which I have placed third, also involves a considerable wound on the face, and is not, in my opinion, advisable. If any skin incision is to be practised at all, I think that the one recommended by Sonnenberg, and for the reasons given by him, is the best, although the operation in which the ramus is trephined probably allows a more free exposure, and excision of a larger amount of nerve. The operation from within the mouth is, however, the one which I think the best of all, for it certainly allows of thorough exposure, and does not leave any scar. I should endeavour to expose the nerve by this operation, before making any skin incision.

As to the danger of any of these procedures, some operations—*e.g.*, those of disarticulating the jaw, or exposing the nerve in the sigmoid notch—necessarily endanger the facial nerve, and in any operation the inferior dental artery may be injured. I am only aware of three cases in which this accident has actually happened. One is recorded by M. Monod,* who at a discussion at the Soc. de Chir. de Paris, said that he knew of a case in which during the intra-buccal operation the hæmorrhage from a wound of the inferior dental artery was so profuse as to necessitate the ligature of the external carotid. The other two instances are recorded by Weir† and Clutton.‡ In one of these the bleeding was arrested by plugging, in the other by the application of pressure forceps for twenty-four hours.

In any of the operations I have mentioned, but especially in that in which the bone is trephined, there may result periostitis or necrosis, and, in the intra-buccal operation especially, the patient may be unable to eat solid food for several days, and the face and neck may be much swollen and inflamed.

The Mental Nerve is readily exposed without any skin incision. The angle of the mouth being retracted, and the lips depressed, an incision should be made through the mucous membrane opposite to the space between the two bicuspid, and parallel to the alveolar border of the gum, but rather nearer to the lower edge of the body of the jaw than to the alveolar margin.

* *Bull. de la Soc. de Chir.*, 1883, p. 84.

† *Annals of Surgery*, June 3, 1887.

‡ *St. Thomas's Hospital Reports*, vol. xv. p. 208.

The nerve will be found emerging from its bony canal opposite to the interval between the two bicuspid.

The Lingual Nerve.—This nerve is not often operated upon, but I think that quite the best means of exposing it is that recommended by Mr. Lucas.*

A suture is passed through the tongue on that side of the septum on which the operation is to be performed. The tongue is somewhat forcibly pulled towards the opposite side of the mouth, and the lingual nerve can then be felt standing out as a firm band beneath the mucous membrane. A sharp-pointed hook is passed under the nerve, and the latter is exposed by snipping the mucous membrane which covers it.

In other cases where the tongue is fixed by cancerous growth the nerve is best exposed where it lies in close contact with the body of the jawbone, and where it can easily be felt as a rounded and tender cord, just beneath the mucous membrane below the first lower molar tooth.

Meckel's Ganglion.—Meckel's ganglion has been exposed by osteoplastic section of the superior maxilla, but this operation is unnecessarily severe.

The better operation is one that has been practised by American surgeons more than by others, and is performed as follows:—

An incision is made in the cheek with its centre opposite the infra-orbital canal. Bleeding having been checked, a portion of the anterior wall of the antrum is removed with a half-inch trephine. A stout bristle, a piece of quill, or a slender probe, is then passed as a guide along the infra-orbital canal, and the floor of the latter is carefully cut away from below with bone scissors until the posterior wall of the antrum is reached. Care should be taken not to divide the nerve, for it is the best guide to the ganglion.

The trephine is next applied to the posterior wall of the antrum, and the bone having been removed, the ganglion will be most easily found by tracing the nerve back until its junction with the latter is reached. With a curved pair of scissors the ganglion may then be separated from its other branches, and removed still attached to the infra-orbital trunk. Should there be troublesome hæmorrhage after the posterior wall of the antrum has been removed, pressure with the finger or a pad of lint should be applied. Bleeding is best avoided by taking great care not to lacerate the tissues pos-

* *British Medical Journal*, 1884, vol. ii. p. 775.

terior to the antrum by the trephine. By the aid of a reflected light, as recommended by Chavasse and Walsham, the deeper part of the operation is rendered easier.

The operation described above is practically that originally recommended by Carnochan, but some modifications have been introduced in the manner of its performance.

The Facial Nerve.—The following operation was first described by Baum,* and is recommended by most surgeons. An incision is made behind the ear, commencing at a point opposite the meatus, and carried at first downwards and forwards to a point immediately below the lobule, then prolonged almost perpendicularly nearly to the angle of the jaw. A small transverse incision can be made, if necessary, below the pinna, at right angles to the first incision. The edge of the sterno-mastoid is exposed, and the muscle is drawn downwards and outwards. The parotid gland is drawn forwards. The posterior auricular artery and vein may require division, as may also a part of the great auricular nerve. The facial nerve will be found immediately above the upper border of the digastric muscle. In order to facilitate the discovery of the nerve, which is small and difficult to distinguish, Dr. Keen † has recommended that the end of a fine electrode should be used, as its contact with the nerve would be indicated by contraction of the facial muscles.

The facial nerve has also been exposed by Hueter by another incision ‡ in front of the ear; but this method is in all respects inferior to that of Baum, the nerve being more difficult to find on account of its having already divided into its chief branches, and on account of the bleeding, which is generally free.

The Spinal Accessory Nerve.—This nerve may be exposed either before or after its transit of the sterno-mastoid muscle. It is more easily exposed in the latter situation.

To divide the nerve before it enters the sterno-mastoid muscle, an incision should be made along the anterior border of the latter from the level of the lobule of the ear for a distance of two inches or a little more. The edge of the muscle being exposed and drawn outwards, the nerve will be seen entering it at a point rather above the level of the hyoid bone.

To expose the nerve after it has passed through the sterno-

* *Berlin. Klin. Woch.*, 1878, No. 40, p. 595.

† *Annals of Surgery*, July 1886.

‡ *Central. für Nervenheil.*, No. 7, 1880.

mastoid, an incision should be made parallel to the posterior border of the latter, with its centre a little below the middle of a line drawn from the mastoid process to the clavicle. It is at this point that the nerve emerges from the muscle.

Superficial Branches of the Cervical Plexus.—The small occipital, the great auricular, and the superficial cervical nerves, may all be exposed readily by incisions along the posterior border of the sterno-mastoid muscle. The two latter branches emerge from behind the muscle at the centre of a line drawn from the clavicle to the mastoid process, and therefore close to the spinal accessory trunk. From the latter they may be distinguished by their direction, for the spiral accessory passes in a downward and outward direction to the trapezius, whilst both the great auricular and the superficial cervical curl forward over the sterno-mastoid muscle, the former passing also upwards, whilst the superficial cervical has an almost transverse direction.

The small occipital nerve is best reached by an incision, with its centre just below the junction of the upper with the lower two-thirds of a line drawn from the clavicle to the mastoid process, parallel to the posterior edge of the sterno-mastoid.

The Brachial Plexus.—The brachial plexus may be exposed either in the neck or in the axilla.

In the former situation the incision may be made either parallel to the clavicle, as in the operation for ligature of the subclavian artery, or else parallel to the anterior border of the trapezius muscle. In either case, the only structures to be divided are the skin and platysma with the superficial and deep fasciæ. The nerve-trunks are readily recognized.

In the axilla, the brachial plexus is reached by an incision in its middle line, parallel to the long axis of the humerus. After division of the skin and fascia the nerves come at once into view.

Nerves of the Upper Arm.—The *Median Nerve* is easily reached by an incision carried along the inner edge of the biceps muscle in the middle of its length. At this place the nerve crosses the brachial artery in a direction from without inwards.

The *Ulnar Nerve* may be exposed by an almost similar incision, but in the middle of the arm will be found lying a little to the inner side of the brachial artery. Below this point it rapidly leaves the vessel, passing inwards, to reach the groove behind the internal condyle of the humerus. In the latter situation the nerve is readily felt, and easily exposed by a small longitudinal incision.

The Musculo-spiral Nerve is most readily reached on the outer side of the arm between the triceps and biceps muscles. The incision should be made in a line drawn from the external condyle of the humerus to the tip of the acromion process, and its centre should be midway between the external condyle and the insertion of the deltoid muscle (Wiet). If the separation between the triceps and biceps is carefully sought for, and these muscles held apart, the nerve will readily be felt rolling over the smooth surface of the humerus, and may be exposed with a few touches of the scalpel. In many cases the cutaneous branch of the musculo-spiral will be first met with, lying also between the triceps and biceps, but placed much more superficially than the trunk of which it is a branch.

Nerves of the Forearm.—The *Median Nerve* is easily reached, close above the wrist-joint, by an incision on the inner side of the palmaris longus tendon, at about the centre of the flexor surface. Only skin and fascia require division, but in its transit to the hand the nerve passes beneath the annular ligament.

The *Ulnar Nerve* may be exposed by an incision through the skin and fascia, on the outer side of the flexor carpi ulnaris tendon, an inch or two above the wrist-joint. In this situation, the ulnar nerve lies a good deal more deeply than does the median, and is further covered by an additional layer of the deep fascia. The ulnar artery lies in contact with the nerve, on its outer side.

The *Radial Nerve* is easily accessible at the place where it passes from under the tendon of the supinator radii longus to the back of the wrist. The centre of the incision should be at a point about three inches above the wrist-joint.

The Great Sciatic Nerve.—To define the course of the great sciatic nerve, draw a line from a point between the great trochanter and the tuberosity of the ischium, but half an inch nearer the latter than the former, to the middle of the popliteal space.

The nerve is most readily exposed by an incision, about three or four inches in length, commencing just above the lower portion of the gluteal fold. The skin and fascia having been divided, together with a good deal of firm fat, the lower edge of the gluteal muscle will come into view. The biceps muscle will then be seen appearing from under the cover of the gluteus maximus. The deep fascia being divided with a few touches of the scalpel, the sciatic

nerve will be readily brought into view by drawing the biceps to the inner side.

In the popliteal space, an incision through the skin and fascia in the middle line will expose either the sciatic nerve itself or else the two main branches—the internal and external popliteal—into which it divides. The external popliteal, or peroneal, nerve lower down tends to pass to the outer side of the space, and here lies in close contact with the inner side of the biceps tendon, then winding round the fibula it buries itself in the muscles attached to that bone.

The Tibial Nerves.—The posterior and anterior tibial nerves accompany the vessels of the same name in their course down the leg.

They may each be exposed by the operations by which the arteries which they accompany are ligatured.

The line of the anterior tibial nerve is a line drawn from a point midway between the head of the fibula and the tubercle of the tibia to the middle of the front of the ankle-joint. After division of the skin and fascia, the outer edge of the tibialis anticus should be carefully sought, the search being often facilitated by noticing the small arterial branches which pass up between the muscles of the leg and indicate the edges of contiguous muscles.

After reaching the interval between the tibialis anticus on one side and the extensor longus digitorum and extensor proprius pollicis on the other, the muscles in question must be separated and held apart, when the nerve will come into view, lying close to the interosseous space, superficial to the anterior tibial artery. In the upper part of the leg this operation is difficult and tedious, on account of the great depth at which the vessels and nerves lie.

The posterior tibial nerve may be readily exposed towards the inner ankle by a curved incision, placed three-quarters of an inch from the posterior border of the malleolus. The nerve lies to the outer side of the artery and veins of the same name, and to the inner side of the flexor longus pollicis.

In the calf the incision should be made half an inch from the inner edge of the tibia, and the skin, fascia, and the tibial origin of the soleus should be divided. The deep fascia of the leg then comes into view, and should also be incised. The nerve will be found lying on the tibialis posticus to the inner side of the vessels in the upper third of the leg, but crossing to their outer side in the middle third.

The Musculo-cutaneous Nerve is easily reached by an incision just below the middle of the leg, in a line drawn from the front of the head of the fibula to the posterior border of the external malleolus. It will here be found emerging from the muscle on the outer side of the leg.

The therapeutical uses of neurotomy and neurectomy are almost limited to cases of neuralgia. To their application and use in this disease I shall again refer when treating of Neuralgia.

In an earlier chapter I have stated my opinion of their uselessness in cases of tetanus, and to this I have nothing to add.

The operation of neurectomy in cases of tumours of nerves will best be considered in dealing with the subject of Neuroma.

CHAPTER XXI.

NERVE-STRETCHING.

THE subject of nerve-stretching is one which has not occupied the attention of surgeons for more than sixteen years, and, indeed, it has excited but little interest until within the last ten or twelve.

First brought into notice by a most successful case reported by a German surgeon in 1872, the operation was in the course of a few years pressed upon the attention of the medical profession by physiologists who had carried out innumerable experiments on various animals. I have no doubt that these experiments were of use in directing attention to a remedy which was but little known, and that without them we should be in ignorance of many anatomical and physiological changes induced by this operation; yet, on the other hand, many of these experiments are much at variance with one another, and the deductions to be drawn from them are by no means clear.

Further, had it not been for some of these experiments, claims, which have been proved to be false, would not have been made on behalf of nerve-stretching, and our present knowledge of its true position, from a therapeutical point of view, would have been attained much sooner.

In investigating the subject of nerve-stretching I have necessarily been led to a study, more or less complete, of the various experiments alluded to above, but it does not appear to me to be either necessary or advisable to criticize them seriatim. The task would be an arduous and a lengthy one; the end attained thereby may be more easily reached. In the following pages I shall endeavour to summarize the net results, and to place them before my readers in as condensed a form as possible. I shall only allude to those experiments which appear to me to be the most important or the most trustworthy, and shall pass over those which seem either unnecessary or misleading.

I propose to treat first of the anatomical and physiological changes which are found to occur after operation, and then to consider the manner in which the operation may be supposed to produce its therapeutical effects. After this, I shall proceed to describe the various morbid conditions for which the operation has been performed, and shall endeavour to assess its value in each.

The Extensibility and Strength of Nerves.—The first experimenter in this field was Paul Vogt. His results were published in 1877.* The investigations were conducted upon the dead body, after the following manner:—

The median nerve having been exposed in its entire length, weights were attached to one end. A weight of three kilogrammes produced a lengthening of two centimetres. A further weight produced a maximum lengthening of another centimetre. After this stretching the nerve returned, by virtue of its elasticity, to its natural dimensions, but in cases where a considerable weight was applied for a great length of time, a permanent lengthening of two millimetres resulted.

The relative amount of extensibility was found to increase the greater the length of nerve operated upon, so that in very short pieces of nerve little or no extensibility could be established, whilst in long portions the increase of extensibility was more than could be accounted for by a simple increase of length in the portions stretched.

The extensibility of the nerve was found to be greatest in the parts nearest to the spinal cord. There was a gradual diminution of extensibility as the periphery was reached. This fact was proved by placing two pins in the nerve at a distance of three centimetres apart in the upper end, and two other pins at a similar distance apart close to the periphery. The whole nerve being then stretched, the pins near the central end were found to have become separated to a distance of six centimetres, whilst those placed at the periphery almost maintained their previous relative position.

The total amount of stretching of which a nerve is capable has been estimated to be about one-twentieth of its whole length. The nerves of the upper extremities are said to be more extensible than are those of the lower.

My own investigations lead me to agree with the above, and I

* *Die Nervendehnung als Operation in des Chir. Praxis.* Leipzig.

think that they are not materially at variance with those of other writers.

The strength or breaking-strain of the nerves has been investigated by various experimenters, and with the widest differences in results.

Perhaps the first thing that strikes the investigator of this subject is the comparatively enormous weights that the nerve-trunks will sustain. All experimenters agree in this, though differing in details.

In 1878 Tillaux* published the results of his investigations on the resistance of the nerve-trunks. As a result of a series of experiments on sciatic nerves entirely separated from the rest of the limb, he found that the breaking-strain to a force applied in the long axis of the nerve was about 112 lb.; that of the ulnar and median under similar conditions varied from 45 lb. to 100 lb. It was noted that the nerves were especially liable to rupture at certain points: thus the median usually broke about the level of the elbow, the sciatic at its exit from the sciatic notch.

Trombetta† gives the following results as the mean of various experiments:—

		Kilogrammes.
The breaking-strain of the	sciatic nerve is	84
"	" internal popliteal	52
"	" crural	38
"	" median	38
"	" ulnar	27
"	" radial	27
"	" brachial plexus in neck	22 to 29
"	" " in axilla	16 to 37
"	" infra-orbital	5½
"	" supra-orbital	2¾
"	" mental	2½

More recently, Mr. Symington, of Edinburgh, has published the results of experiments made on the sciatic, in which the force was applied in a line transverse to the long axis of the limb,‡ the method of procedure being as follows:—

The nerve having been exposed, the corpse was placed on its back, and the buttocks and knees supported on blocks. An S-shaped hook was then passed around the nerve, and weights

* *Affect. Chir. des Nerfs.* † *Sulla Stiramento delli Nervi*, 1880.

‡ *British Medical Journal*, May 27, 1882.

were rapidly added until it gave way. In eight adults the average weight required to produce this result was $140\frac{3}{4}$ lb., and the author concludes that a loop of the sciatic would, as a rule, support the weight of the body for a short period. As Mr. Symington remarks, the spot at which the rupture occurs is of considerable interest, and his conclusions are at variance with those of Tillaux, already quoted, for in eight cases the nerve itself did not break, but its connections with the spinal cord and membranes were detached, the nerve-roots being torn out from their attachments to the medulla.

On opening the spinal canal and observing its contents during the operation, it was found that the main strain was borne by the dura mater where it was continuous with the nerve-sheath, and that but little traction was exercised on the spinal cord itself. Should the dura mater, however, become torn, a very slight force was found sufficient to tear the roots from their connection with the cord.

In the six other cases operated on the nerve broke at the point where the hook was applied.

In 1883 Gillette* published the results of numerous experiments which had been conducted by himself on the breaking-strain of nerves. He found that it differed much in different subjects, and that this difference appeared to bear some relation to the cause of death and the condition of the body experimented upon. He tabulated his results as follows:—

Experiments on Stretching the Sciatic Nerve.

	Weight used. Kilogrammes.		Weight used. Kilogrammes.
Seven patients who died of heart disease. Nerve-roots torn out, but nerve not torn.	$\left\{ \begin{array}{l} 200 \\ 133 \\ 130 \\ 110 \\ 110 \\ 105 \\ 95 \end{array} \right.$		$\left\{ \begin{array}{l} 135 \\ 125 \\ 115 \\ 110 \\ 105 \\ 95 \end{array} \right.$
Did not break in healthy man of 40 years	$\left\{ \begin{array}{l} 200 \\ 200 \end{array} \right.$	Patients who died of cancer. Nerve torn.	$\left\{ \begin{array}{l} 90 \\ 87 \\ 83 \\ 73 \\ 65 \\ 61 \\ 42 \\ 2 \end{array} \right.$
In five paralytics, nerve torn out, not broken.	$\left\{ \begin{array}{l} 130 \\ 100 \\ 100 \\ 75 \end{array} \right.$		
Separated at insertion into cord.			

* *Bull. de la Soc. de Chir.*, 1883, p. 165.

Experiments on the Sciatic Nerve.

	Weight used. Kilogrammes.	Weight used. Kilogrammes.
The nerve broke	165	95
	130	90
	120	90
	115	85
	115	78
	110	66
	105	60
	100	45

Stintzing,* in his valuable memoir on nerve-stretching, has shown that the breaking-strain varies not only within the wide limits already indicated, but that it is greater in the living than in the dead animal. In one case which he mentions the breaking-weight of the sciatic in a dead animal was found to be equal to about half its body-weight, whereas in another living animal it amounted to 1.8 of the body-weight.

In his Bradshaw Lecture on nerve-stretching, Professor Marshall† summarizes some of the experiments in the following table:

*Cohesion of Nerves.—Breaking-strain in Pounds.
Human Nerves after Death.*

	Lbs.		Lbs.
Supra-orbital	6	Crural	83
Infra-orbital	12	Internal popliteal	114
Mental	5½	Great sciatic—Symington	86-176
Brachial plexus	50-64	" Tillaux	118-127
Ulnar	58	" Gillette	165
Musculo-spiral	61	" Trombetta	82-288
Median	84	" Ceccherelli	154-220

That the various experiments should have yielded varying results is only what might have been expected. The breaking-strain of muscles, tendons, and of bones also differs materially under different conditions and in different subjects.

It is well known that the resisting power of all tissues is much greater during life than after death. This is always very noticeable in the muscles, and appears to be true of the nerves to a less extent.

The condition of the body experimented on must of necessity exercise the greatest possible influence on such a subject. In a powerfully built, robust man, who has been killed by an accident, the cohesion of all the tissues is much greater than in an enfeebled

* *Ueber Nervendehnung.* Leipzig, 1883.

† *British Medical Journal*, 1883, vol. ii. p. 1173.

person who has died a lingering death. In the young the tissues are both stronger and more elastic than in the old, and if experiments be conducted soon after death the difficulty of tearing any structure is much greater than where decomposition is in progress.

In view of such considerations it is to be expected that experiments, conducted on bodies of all kinds and in widely differing states, should yield very varying results.

Nevertheless, these results possess an undoubted value of their own, and provided that it is understood that, from their nature, they cannot be accurate in every particular, they afford much useful information with regard to the amount of stretching to which any given nerve can be safely subjected.

In connection with this question of the resisting power of nerves, another point has arisen, and has obtained very undue prominence. It is whether or no the spinal cord can be *mechanically* influenced by stretching of the peripheral nerve-trunks.

The following is a brief summary of the evidence collected from various sources respecting the effect of nerve-stretching upon the cord:—

Harless and Haber state that the cord is not moved by pulling on the nerves. Vogt agrees with this statement. The brothers Fieber saw the cord move upon their forcibly flexing the thigh, the knee being extended. Gussenbauer saw both the cord and the medulla move on stretching the sciatic. Braun found that the cord moved different amounts at different heights, and concludes that the cord moves about one-twelfth of an inch in the lumbar region and one-seventieth at the first dorsal. The cord is therefore stretched. Dana found that, at the level of the first lumbar, there was a movement of the cord downwards of about one-fifteenth of an inch; at the level of the sixth dorsal a movement of one-twentieth of an inch. In these experiments the leg was extended upon the thigh and the thigh flexed upon the trunk. The sciatic nerve, in another experiment, was exposed and drawn upon directly. It was found that a pull of 20 lb. moved the cord perceptibly, and a pull of about 50 lb. caused a slight, hardly perceptible movement of the medulla. The movement of the cord on pulling the sciatic was slightly less than that obtained by subcutaneous stretching. In a cat a traction of 10 lb. caused the cord and dura mater to move very perceptibly.*

* *New York Medical Record*, vol. xxii. p. 113.

Gillette* is of the opinion that the cord may be moved by stretching the sciatic nerve in the dead human subject.

Professor Marshall† and Mr. Horsley are of opinion that traction on the sciatic in the corpse does not cause any perceptible movement in the cord.

In the opinion of most of the writers who deny that the cord itself can be stretched, the effect of the stretching is not perceptible above the membranes, as far as which they consider that it can be propagated.

I have repeated the experiments myself on various dead bodies, and only once have I seen any considerable movement occur in the cord. In this case the force used was so great that the nerve itself broke. In several other cases I have observed slight movements.

For my own part, I have no doubt that there is a certain amount of right on both sides. Where the nerves are strong enough to bear a very excessive traction, a certain amount of movement may be propagated to the spinal cord. Where the nerves are weak they break before the necessary amount of force can be applied.

Again, my own experiments have satisfied me that the amount of rigor mortis materially influences the result. When all the muscles of the gluteal region and of the thigh are firmly contracted, the amount of lateral pressure exercised upon the nerve-trunk is so great as to prevent the effects of the stretching being propagated to any distance.

And, again, the conditions differ materially in the living and the dead. In the former, the cellular tissue around the nerve is loose and yielding, in the latter it is much denser and firmer.

I cannot doubt that the influence of nerve-stretching is propagated to a greater distance before than after death.

But, looking at the matter from a practical point of view, the amount of stretching required to affect the spinal cord is infinitely greater than would be used by any cautious surgeon. And it must be remembered that, even supposing the cord could be mechanically influenced by traction applied to the sciatic, this conclusion does not apply to the other and smaller trunks, all of which would break before sufficient force could be applied.

To this latter remark one exception must be made. If the brachial plexus be exposed in the neck the cord can certainly be drawn upon if sufficient force be applied.

* *Loc. cit.*

† *Op. cit.*

Anatomical Changes caused by Nerve-stretching.—

The anatomical changes caused by nerve-stretching were first investigated by Harless and Haber (in 1858*), who noticed that the sheath became tighter and appeared to exercise some constriction on the contained tubules.

In 1864 Valentin confirmed this observation, and extended the investigation. He showed that the nerve-tubules were both elongated and narrowed, and that the stretched nerve was quite capable of returning to its normal calibre.

In 1877 Vogt† described various changes which he had seen to occur in the connective tissue of the nerve-trunk. He found that at the place where the stretching had been performed there was effusion of blood from the vessels of the perineurium, and that the nerve-trunk was loosened from its attachments to the sheath. Both above and below the seat of operation there were found similar ecchymoses which, in the case of the sciatic nerve, were most marked in the popliteal space, and at the exit of the nerve from the sciatic notch. The vessels which were not torn were found tortuous and dilated, and not only did this dilated condition tend to persist, but within a week or two numerous new blood-vessels were formed, and the nerve-trunk which had been stretched became much more vascular than it was before the operation.

Latteaux‡ arrived at similar conclusions to Vogt, and further described a cell proliferation in the perineurium, with degenerative changes in the peripheral nerve-bundles themselves.

Quinquaud and Scheving,§ in 1881, showed that, as far as the nerve-tubules themselves were concerned, the changes induced by nerve-stretching were the same as those which followed on section. The extent of these changes depended upon the amount of stretching to which the nerve had been subjected.

On the fourth day after operation the nuclei of the sheath had proliferated, and the myeline had become segmented. In another animal, twenty-five days after the nerve had been stretched, it was found that the degeneration was most marked in the fibres near the surface, those in the centre being in places yet intact. On the forty-fifth day not only were there many tubes in a state of advanced degeneration, but a few apparently newly formed fibres could be distinguished.

The degeneration of nerve-fibres was most marked in the

* *Zeit. für Rat. Med.*, 1859, p. 446. † *Loc. cit.* ‡ *Thèse Duvault*, 1876.

§ *Thèse Schering*, 1881; and *Compt. Rend. de la Soc. de Biol.*, 1881-2, vol. iii. p. 119.

central portion of the stretched nerve, and extended as high as the junction of the two roots, though whether the latter were themselves affected is not clear.

Marcus* examined nerves which had been subjected to stretching at various times after the operation had been performed. From the third day after the operation he found some nerve-fibres which appeared intact and others in which the myeline was segmented, and in which the loss of continuity from absence of the axis cylinder left no doubt of their degeneration. Other tubes, again, he found filled with a granular transparent substance. In some of these, whose myeline had disappeared, the sheath had fallen in and lay in contact with the axis cylinder.

Marcus also noticed a great increase in the number and size of the nuclei of the neurilemma. In the nerve of a cat, eight days after operation, the lesions just described were found to be limited to the central end of the nerve operated on, while the peripheral end remained normal. In another cat, which was examined four days after operation, there was found to be no change in the nerve whatever, although anæsthesia was complete.

Wiet† also described degenerative changes such as are met with in cases of section, and which I have already described in dealing with the pathology of nerve-injuries. Both Marcus and Wiet have observed that, in cases of forcible stretching, not only is there a tendency to segmentation of the myeline and to breaking of the sheath of Schwann, but that the axis cylinders themselves may be torn across.

In this country the breaking of the nerve-tubules and segmentation of myeline above mentioned, as well as the apparent constriction of the nerve-fibres by the sheath, described by Haber and Harless, have been confirmed by Professor Marshall and Mr. Horsley.‡

Tarnowski, in a paper to which I shall again refer, confirms the fact that the changes that occur in the individual nerve bundles and tubules are of exactly the same character as those met with after section, and further shows very clearly that the amount of these degenerative changes in the peripheral end bears a direct relation to the force with which the nerve has been stretched.

This author finds that all the degenerative changes are much more marked in the peripheral end of the stretched nerve than in the central end.

* *Compt. Rend. de la Soc. de Biol.*, 1882, vol. iii. p. 110.

† *Thèse d'Agrégation*, 1881.

‡ *Loc. cit.*

The following conclusions may be drawn as to the anatomical changes caused by nerve-stretching:—

First. The sheath is partly loosened from its attachment to the nerve, and at the same time is narrowed, and so constricts the nerve-tubules.

Second. The blood-vessels of the sheath are torn, and ecchymoses occur. The vessels become tortuous and dilated, and after a time the nerve-trunk becomes more vascular by reason of the formation of new blood-vessels.

Third. There is an increase of the connective-tissue cells of the sheath.

Fourth. The nerve-tubules themselves may be more or less torn. The axis cylinder breaks less easily than does the myeline sheath and the sheath of Schwann. The peripheral tubules suffer more injury than the central ones.

Fifth. As a result of the injury inflicted upon the nerve-tubes, degeneration, with segmentation of myeline, multiplication of nuclei, and breaking up of the axis cylinders ensues in a similar manner to that which follows upon section.

Sixth. New nerve-tubules are formed and the nerve becomes completely regenerated. This occurs much more rapidly than when the nerve has been completely divided.

Seventh. Quinquaud has noticed in some cases a thickening of the fibrous tissue of the sheath, and a secondary degeneration of the nerve-tubules, due to their compression by the newly formed fibrous tissue.

Changes in the Spinal Cord induced by Nerve-stretching.—Although other investigators had examined the condition of the spinal cord after interference with the peripheral nerves, the first complete description of any morbid changes in the spinal medulla was recorded by Hayem.*

M. Hayem avulsed the sciatic nerve in two young rabbits, and killed the animals two months later.

A microscopical examination of the spinal cord showed a general atrophy of the lateral half on the side on which the operation had been performed.

In the grey matter the nerve-cells were found to be shrunken, and the nerve-fibres were constricted by an increase in the connective tissue of the neuroglia.

* *Archives de Physiologie*, 1873, vol. i. p. 504.

In the white matter, the atrophic changes were most marked in the columns of Goll and the postero-lateral tracts.

These conditions were considered by Hayem to be due to a myelitis started by the injury which the tearing out of the nerve had inflicted upon the spinal cord.

In a further communication to the Société de Biologie in 1874, the same experimenter showed that the degenerative changes mentioned tended to spread up the whole length of the cord.

In 1877 Mayser* confirmed the descriptions of Hayem. In his cases also the sciatic nerves were completely torn out.

In the *Archives de Neurologie* for May and July, 1885, is a most careful and elaborate paper by Dr. Pauline Tarnowski, embodying the conclusions arrived at after more than forty examinations of spinal cords removed from animals at varying times after the operation of nerve-stretching.

The animals experimented upon were rabbits, the amount of the stretching force was measured in each case, and varied from 500 grammes to 5 kilos. The sciatic nerve was always the one experimented upon. The animals were killed at times varying from forty-eight hours to six months after operation.

In those cases in which not more than a weight of 500 grammes had been used to stretch the nerve, the only change found in the cord was a simple and transient hyperæmia, which left no permanent traces of its occurrence.

In cases in which weights of 4 to 5 kilos had been used, the operation was followed by hæmorrhages and myelitis. About the seventh day these changes resulted in the formation of fibrous tissue which extended in the form of a network and compressed the nerve elements. The column of Goll on the side on which the stretching had been performed was always the part first affected by the sclerotic change. The columns of Burdach and the intramedullary portions of the posterior roots were next affected. Gradually, the whole of the posterior columns were implicated by the invasion of fibrous tissue and constriction of the nerve elements, so that in time there was established a definite atrophy of the whole of the posterior column.

In the grey matter similar changes were seen—namely, hæmorrhages and inflammatory exudation soon after the injury, and sclerosis with atrophy of the nerve-cells after an interval of time. These changes were more marked in the posterior than in the

* *Arch. für Psychiat.*, 1877.

anterior horns, but even in the latter the destruction of cells with vacuolation was evident.

Amongst other changes there were seen a distension of the central canal with a plastic exudation, and a multiplication of the nuclei of the neuroglia.

All the changes enumerated were most marked in the lumbar region, and never affected the side of the cord opposite to that on which the traction had been made.

The author considers that the lesions described are due to the mechanical interference with the cord in the act of stretching.

The communication of which I have given the above summary appears to be one of much importance, and I am inclined to credit entirely the accuracy of the observations.

Physiological Effects of Nerve-stretching.—The physiological effects of nerve-stretching have been studied by very numerous experimenters, and after much controversy certain definite results have been obtained, whilst many others are still under debate.

In 1858, Harless and Haber* published a short paper on this subject, and their conclusions were confirmed and elaborated by Valentin,† in 1864. The latter observer was followed by Schleich in 1871,‡ and by Tutscheck in 1875.§ The conclusions of the latter observer agreed with and supplemented those of his predecessors, and may be shortly summarized, as follows:—

First. In a decapitated frog, a slight stretching of the sciatic nerve causes a slight increase of the reflex excitability of the limb.

Second. A further and stronger stretching reduces the abnormal excitability.

Third. An increase of the stretching depresses the excitability below normal.

Fourth. Very strong stretching destroys the excitability.

Fifth. The *direction* in which traction is made affects the result. If traction be made in a direction away from the cord anæsthesia is more marked than paralysis. If the traction be made in the opposite direction the reverse conditions obtain.

In 1877, Conrad|| arrived at the same conclusions, and also

* *Op. cit.*

† *Versuche einer Physiol. Pathol. der Nerven*, 2 Abtheil. 1864.

‡ *Zeit. für Biol.*, Band vii. 1871.

§ *Inaug. Dissert. München*, 1875.

|| *Inaug. Dissert. Griefswald*, 1876.

expressed his opinion that the sensory functions were more easily interfered with by nerve-stretching than were the motor functions. Both this author and Duvault* showed that almost complete anæsthesia might be caused by stretching, and that sensation might subsequently be rapidly restored.

Tarchanoff,† Laborde,‡ and Quinquaud,§ in the following years published the results of further experiments. They showed that not only was sensibility affected in varying degrees according to the force of the stretching, but that the motor functions were also more or less impaired. When the stretching had been vigorous, the anæsthesia might persist for weeks.

In 1881, Wiet|| showed that although after a moderate stretching there was no reflex contraction caused by pinching the toes supplied by the stretched nerve, yet that the limb was readily moved when another part of the body or limb was irritated.

Not only may the sensory and motor functions be interfered with, but trophic changes, similar to those met with after nerve section, may occur in the parts supplied by the stretched nerve.

These were first noted by Quinquaud and recorded in the *Comptes Rendus de la Soc. de Biol.* (1881-2, vol. iii. p. 120). The trophic changes consisted in the ulceration and falling off of the toes.

Undoubtedly the best description of the physiological results of nerve-stretching is to be found in the monograph by Stintzing, of which the following is a very brief summary :

The author concludes that the stretching of a mixed nerve produces a paralysing action in the sphere of distribution of this nerve. This paralysing action affects equally mobility, sensibility, and trophic and vaso-motor influences. The degree of paralysis is proportionate to the force with which the stretching has been done. The symptoms are essentially those of degenerative atrophy of the muscles. Relatively to the electrical reaction on stretching nerves, the author observes that the excitability of the sciatic by induced and continuous currents disappears from the second to the sixth day when the stretching has been violent, sometimes even on the first day. The diminution of excitability appears first in the trunk of the sciatic, then in its branches, and then later in the peroneal branch. Even when it has completely disappeared excitability may reappear about the eleventh to the fifteenth week.

* *Thèse d'Agrégation de Paris*, 1876.

† *Thèse Scheving.*

‡ *Soc. de Biol.*, Feb. 5, 1881.

§ *Op. cit.*

|| *Op. cit.*

When the stretching has been slight, the electrical reactions in the muscles present no modifications. One can notice sometimes a slight diminution of irritability, sometimes complete reaction of degeneration; but the appearance of this last is not general. Thus, if the stretching has been great, reaction of degeneration may show itself in the first few days: if not, at the end of six weeks.

The diminution of sensation is, speaking generally, proportionate to that of movement. As far as the trophic troubles are concerned, they do not appear except after very vigorous stretching. The one which is noticed first is atrophy of the muscles, which may make its appearance in the first week. The stretching of the nerve has also an influence upon the same nerve of the opposite side, and causes an increased excitability in both its sensory and motor filaments.*

It will thus be seen that the lesions and physiological changes that occur after nerve-stretching are much what might be expected, when we consider that the effect of the operation is to cause a partial or complete tearing of the nerve-tubules, and degenerative changes such as usually follow after section.

The amount of these changes will depend upon the amount of the stretching, and it seems probable that the functions of the sensory fibres are more easily interfered with than are those of the motor.

Another point remains for consideration, and is one which has given rise to much discussion and difference of opinion. It concerns the effect produced by nerve-stretching on the functions of the spinal cord.

Quinquaud,† in 1881, described the occurrence of certain phenomena which followed on nerve-stretching, and to which he gave the name of "Transfert Mécanique." According to this author, if the right sciatic nerve be stretched to a sufficient extent to cause slight anæsthesia, a rapid return of sensation may be induced by stretching the sciatic nerve of the other side.

In a further communication the same author showed‡ that anæsthesia could be produced in the left limb as well as in the right by stretching the right sciatic nerve. The anæsthesia on the left side was, however, very transitory.

In another experiment Quinquaud first produced a certain

* *Ueber Nervendehnung*, Leipzig, 1883.

† *Soc. de Biol.*, March 19, 1881. ‡ *Ibid.*, April 23, 1881.

amount of anæsthesia by stretching the ulnar nerve, and found that it disappeared on a subsequent stretching of the sciatic.

Brown-Séguard * adduced further evidence of the effect of nerve-stretching in the functions of the spinal cord.

He found that after a transverse section of the right side of the spinal cord in the dorsal region, there ensued anæsthesia of the left hind-leg, and hyperæsthesia of the right. Stretching of the left sciatic restored sensation in the left limb, and half an hour later there was hyperæsthesia of the same side.

The same observers also satisfied themselves that after producing epilepsy in certain animals by a section of the sciatic nerve, the epilepsy could be cured by stretching the proximal end of the divided nerve.

These experiments have been repeated by others with contrary results.

Prévost,* in an excellent memoir, denied that the results of Brown-Séguard and of Quinquaud were accurately deduced. He did not find that stretching of one nerve restored the lost sensation in a part supplied by another nerve previously stretched. Nor did he find any restoration of sensation in the parts rendered anæsthetic by section of the cord to result from stretching of the sciatic.

Debove and Laborde ‡ also investigated the claims made by Quinquaud and Brown-Séguard, and did not obtain the results described by them.

Wiet § investigated afresh the claims of Brown-Séguard relative to the cure of artificially induced epilepsy by nerve-stretching, and again with a negative result. He concluded that there was no evidence that this form of epilepsy was amenable to nerve-stretching.

Finally, Stintzing, after further elaborate investigations, concluded that not only does stretching of the nerve on one side not induce anæsthesia of the other, but that it causes an increase in the excitability of both the sensory and nervous functions on the side opposite to the one on which the operation has been performed.

From a careful consideration of the claims of the different

* *Soc. de Biol.*, Jan. 29, 1881.

† *Rev. Méd. de la Suisse Romaine*, 1881, p. 469.

‡ *Gaz. Méd. de Paris*, Feb. 19, 1881.

§ *Op. cit.*

authors I have quoted, I feel convinced that the very extraordinary results claimed by Brown-Séquard are not to be depended upon. They are contrary to all we know of the functions of the spinal cord and of the nerves, and have not been confirmed by subsequent investigations.

In my opinion, any conclusions drawn from experiments on animals as to the amount of anæsthesia and hyperæsthesia present at any one time, must be open to the most serious error. The animals are quite unable to express themselves except by cries or by movement, and the most erroneous opinions may be formed, especially if the investigator is on the look-out for the confirmation of previously conceived ideas.

In the human subject, however, the question of anæsthesia or of motor changes is readily settled. With the exception of the sciatic, no cases of reflex anæsthesia or paralysis have been noticed after nerve-stretching, and it may safely be concluded that the results of the operation, whatever they may be, are limited to the distribution of the nerve operated upon.

But in the case of the sciatic nerve there have been noticed in rare instances alterations in the motor and sensory functions of nerves on the opposite side of the body, and corresponding to those which have been stretched.

Thus, Fenger and Lee* describe a case in which, after stretching of the left sciatic nerve for the cure of sciatica, there was temporary anæsthesia in the distribution of the small sciatic nerve on both sides, with paralysis of the sphincter ani. I have seen precisely similar results after stretching of the right sciatic for a similar cause, and should conclude that these cases supply sufficient evidence to show that in stretching of the sciatic nerve some effect may be produced upon the spinal cord, but that there is no evidence of such a result in the case of the other nerve-trunks. Perhaps this is what might have been expected from a consideration of the mechanical effect produced on the cord by forcible stretching of the sciatic.

Mode of Action of Nerve-stretching employed as a Method of Treatment.—The following are the chief theories as to the mode of action of nerve-stretching when employed as a method of treatment. It may act :

First. By causing an increase in the vascularity of the nerve-

* *Journal of Nervous and Mental Diseases*, New York, April 1881.

trunk the nutrition of the latter is improved, and its functions are performed in a more vigorous manner (Vogt).

Secondly. By separating the nerve-trunks from any abnormal adhesions, or from pressure by surrounding cicatricial tissue.

Thirdly. By restoring to the nerve-centres their proper control of the functions of the peripheral nerves (Callender). This theory may be further explained. The author is of opinion that by long-continued peripheral irritation the peripheral nerves may, so to say, become emancipated from their reliance upon the central nervous system. By the temporary arrest of the conveyance of abnormal impressions the centres may regain their influence over the nerves which have been stretched.*

Fourthly. By causing changes in the trophic cells situated in the nerve-ganglia and in the spinal cord, whereby alterations in the trophic conditions may be induced in the nerve-fibres as well as in the parts to which they are distributed.

Fifthly. By causing traction on the *nervi nervorum*, and by separating them from any abnormal adhesions which they may have contracted to the sheath (Marshall). This theory has been advanced in order to explain more particularly the action of nerve-stretching in cases of neuralgia.

Sixthly. By the partial or complete laceration of the nerve-fibres in the different nerve-bundles. In this case the action of nerve-stretching would closely resemble that of neurotomy.

It is, in my opinion, most probable that several of these explanations are correct, and I believe that in many cases the results of nerve-stretching are obtained by its action in several directions.

The theory that the good effects of nerve-stretching are due to an improvement in the nutrition of the nerve, brought about by an increase in its vascularity, is incapable of definite proof or refutation. If Anstie is correct in saying that neuralgia is "the prayer of the nerve for blood," then it is probable that the increased vascularity described by Vogt may be directly beneficial. It is evident, however, that the good results obtained by nerve-stretching in other cases cannot all be so readily explained.

I feel quite certain that by the second theory many of the satisfactory results of nerve-stretching can be most satisfactorily explained. It is evident that when a nerve-trunk is more or less compressed by scar tissue, or fixed by adhesions, the mechanical

* *Lancet*, 1875, vol. i.

separation of the nerve is likely to be beneficial, and in this way I should explain the many recorded improvements resulting from nerve-stretching in cases of pressure by cicatrices, neuralgic pains following injuries, and the pains caused by the presence of traumatic neuromata adherent to the surrounding tissues. There can here be no doubt that the nerve is compressed by, or adherent to, the surrounding tissue; and there can equally be no doubt that the operation is capable of freeing the trunk from these abnormal conditions.

The third theory of Callender is hypothetical, and, in my opinion, may well account for the benefits derived from the operation in question when applied to the treatment of neuralgias.

Of the fourth theory I would say that it may be true, but that there is no proof of its truth. The fact that changes can be induced in the cord itself by nerve-stretching does not of itself prove that these changes are beneficial, a conclusion which many authors have arrived at.

Mr. Marshall's theory regarding the action of nerve-stretching on the *nervi nervorum* has much to recommend it. As I have already said, it is only applicable to the explanation of the results obtained in cases of neuralgia. Mr. Marshall himself writes of it: "We speak of neuralgic pain as if there was something peculiar or striking about it. So there is, seeing that it is pain in the nerve; but all pain is in nerves. The periosteum does not feel pain except through its nerves. So with the skin, muscles, and tendons—nothing feels pain except through its own nerves. And here, I contend, the argument is strong in favour of the idea that there are really these *nervi nervorum* in the sheath of a nerve. . . . I would also venture to point out that we must consider neuralgia, I think at any rate in some cases, as not a pain in the nerve-tubules (otherwise it surely would be referred to the extremities of those nerve-fibres), but as a pain in the nerve itself, and this I think points out that it must be pain due to what I have ventured to call the *nervi nervorum*."

That these facts are true in reference to some forms of neuralgia cannot, I think, be doubted; but, as Mr. Marshall himself says, they do not apply to all; for, in many cases of neuralgia, the pain is very distinctly referred to the periphery, and, moreover, is excited by peripheral irritation. It is evident that in such cases the presence of abnormal conditions of the *nervi nervorum* can have nothing to do with the causation of the pain.

There is but one more theory to deal with, that which refers the good results of nerve-stretching to the rupture of the tubules in the nerve-trunk. For my own part, I have no doubt whatever that this is the true explanation of many of the cases of relief to pain or to spasmodic movement. The fact that the pain or spasm only lasts so long as the paralysis of motion or of sensation, in many cases, is conclusive. The relief afforded to neuralgic pains, to those met with in *tabes dorsalis*, and the relief of facial or other spasms, are, in my opinion, very frequently due to the mechanical lesions of the nerve-fibres. Moreover, I can well conceive that if any nerve-centre be, so to say, broken of a vicious habit for a time, a permanent cure may result even after reunion of the divided fibres. But if simple section were all that was required, no doubt it would be better to perform the operation of neurotomy or neurectomy. Apart, however, from the serious injury done to a limb by section of one of its nerve-trunks, and the fact that such an operation may result in evils worse than the original disease, nerve-stretching is yet superior to neurotomy.

In writing of the anatomical results of nerve-stretching, I have described the rupture of the nerve-fibres, but it is to be remembered that their continuity is destroyed in more places than one, and, what is of more importance, the mechanical effect is propagated to the branches in the immediate vicinity. So that in the performance of nerve-stretching we really tear the tubules, not only in the trunk we operate upon, but also in other branches which are perhaps difficult to reach with the knife. Thus, in stretching the infra-orbital nerve, I feel sure that the branch passing down to the teeth in the floor of the orbit is also stretched. In stretching the inferior dental, the branches to the teeth themselves are influenced; and so in the case of other nerves.

For my own part, I am inclined to lay more stress on the mechanical rupture of the nerve-tubules, as a therapeutical means of cure, than on the various, and often fanciful, theories which I have already mentioned.

The Operation of Nerve-stretching.—The method of performing the operation of nerve-stretching is very simple. I have already alluded to the best means of exposing individual nerves, and, for the present, shall merely point out the steps of the operation of nerve-stretching as generally performed.

The administration of anæsthetics has been objected to in these cases by French authors, in my opinion, without any sufficient

reason. I have seen no unusual difficulties or dangers ensue with regard to the administration of either ether or chloroform, and should certainly not withhold them.

It is usually advisable to render the limb bloodless by the application of Esmarch's bandage. The nerve should then be exposed by the incision which is considered best suited for its exposure, and thoroughly separated from the tissues in which it lies.

If the nerve-trunk be a large one, the finger, or two or three fingers, should be passed beneath it, and steady traction should be exercised, first in one direction and then in the other. The amount of force employed must vary with the size and strength of the nerve. Even for the sciatic I do not think the force should exceed thirty or forty pounds. As the nerve yields, a sensation of crackling and snapping is transmitted to the fingers, and need not cause any alarm to the operator.

French surgeons have introduced a hook with a spring balance attached to estimate the force employed. I should personally always prefer to use my own fingers.

When the nerve is small, and the wound narrow—as, *e.g.*, in operations on the face—the nerve is best lifted up and stretched by passing an aneurysm needle beneath it.

When Esmarch's bandage has been used, it should be remembered that the effect of stretching cannot extend beyond that part of the limb which remains constricted by the elastic cord. If considered advisable, the latter should therefore be removed.

Bloodless Stretching of Nerves.—In the case of the sciatic nerve, stretching can be done without any incisions being necessary.

If the thigh be flexed on the abdomen, and the leg be kept extended upon the thigh, the sciatic nerve, together with all the tissues on the back of the thigh, is put on the stretch. This can be proved by experiment upon the dead body, and may further be tested as a therapeutic means. The results are often quite as satisfactory as those obtained by making an incision down to the nerve before endeavouring to stretch it.

As far as I am aware, the sciatic nerve is the only one which can thus be stretched without the necessity of previous incisions.

Dangers of Nerve-stretching.—In all operations in which wounds are inflicted, the patient of necessity runs certain dangers common to all injuries which involve a breach of surface. The operation of nerve-stretching forms no exception to the general

law, but inasmuch as the wounds are generally clean incisions, they are not specially liable to the complications to which I allude.

With these complications, which are common to all wounds, I do not propose to deal, but rather wish to direct attention to such as are special to the operation of nerve-stretching.

There is but one local lesion to which I would direct attention—namely, that the injury to the parts is not limited to the seat of the wound.

When the nerve is stretched, it is separated more or less from its sheath, and this separation is necessarily accompanied by a certain amount of laceration of the connections between the sheath and the nerve-trunk. As a result of this, suppuration may extend along the course of the stretched nerve, and pus may thus pass for considerable distances from the seat of the wound. Thus, I have seen an abscess which extended from the sciatic notch halfway down the thigh after stretching of the sciatic nerve.

It is only necessary to know of this source of trouble to combat it effectually. Care should be taken not only that the wound is kept aseptic, but that the skin wound should not be allowed to heal until it is certain that the deeper parts are sound. If pain or fulness be felt in the course of the stretched nerve, there is the more necessity for this caution.

Apart, however, from the dangers of suppuration along the course of the nerve, there are other and more serious dangers to be considered in connection with the question of nerve-stretching.

I allude to inflammations or hæmorrhages of the spinal cord or membranes, which, with their associated symptoms of myelitis or meningitis, may ensue on the operation of nerve-stretching. Fortunately such dangers are rare, and only occur in connection with operations on the larger trunks.

In some cases there is evidence of some lesion of the cord without the supervention of a fatal termination. Thus Israel* records an instance of paralysis of the muscles of the opposite thigh ensuing upon stretching of the sciatic nerve; and Benedict reports a case in which the same operation was followed by paralysis of the bladder and severe vomiting. I have already mentioned a case recorded by Fenger and Lee in which paralysis

* *Centr. für Chir.*, Jan. 28, 1882.

of the sphincter ani followed stretching of the sciatic nerve, and I have seen another case myself in which severe cystitis, with incontinence of urine and fæces, and with paralysis of sensation in a part of the opposite thigh, followed on stretching of one sciatic nerve.

But in other instances a worse result may ensue, and I have here appended a short account of some cases in which death appeared to have been directly due to the operation itself. The nerves operated upon in the various cases were the sciatic, the crural, and the brachial plexus.

*Berger.**—In a man suffering from hemiplegia the sciatic nerve was stretched with a force amounting to about eight or nine kilogrammes. The operation was done with Listerian precautions, but the next day there was gangrenous inflammation in the neighbourhood of the wound, and some hours later the patient died comatose. At the post-mortem examination suppurative inflammation of the spinal cord and its membranes was found.

Fenger.†—Both sciatics and both crural nerves were stretched for the relief of tabetic pains in a man, aged fifty-four. The wounds healed well, but a month after the operation large bed-sores formed over the sacrum, and three weeks later the patient died.

Gussenbauer‡ records a case of tabes treated by nerve-stretching. Soon after the operation there was disturbance of the heart's action and of breathing, followed shortly by suppurative nephritis and death. A post-mortem examination showed submeningeal hæmorrhages in the spinal canal, with inflammatory adhesion between the meninges.

Hierschfelder.§—In a patient suffering from tabes both sciatic nerves were stretched for the relief of pain. Two days later the patient was seized with severe epileptic convulsions, and died comatose on the fourth day after operation.

Kulenkampf|| records a case in which nerve-stretching resulted in the death of the patient. The operation was undertaken for severe pains occurring in a tabetic subject. Both sciatics were strongly stretched under antiseptic precautions, the operation

* *Bull. et Mém. de la Soc. de Chir. de Paris*, 1884, p. 965.

† *Op. cit.* ‡ *Prag. Med. Woch.*, March 15, 1882.

§ *Noch. Elongation des Nerfs*, 1881.

|| *Berlin. Klin. Woch.*, 1881, No. 48.

being followed by excruciating pain. Cystitis with fever supervened on the following day, and continued until the death of the patient seventeen days after the nerves had been stretched. In the opinion of the operator, the cystitis was analogous to that which is met with in injuries of the spinal cord, and was due to injury of the sacral nerves by violent stretching.

*Rumpf** communicated to the Eighth Congress of German Neurologists a case in which, after both sciatics had been stretched for tabetic pains, the patient died on the ninth day. A post-mortem examination showed a recent hæmorrhage beneath the pia mater in the lower dorsal region of the spinal cord.

Rosenstein† records a case in which both sciatic nerves were stretched in a case of tabes dorsalis. The operation was followed by suppuration of one of the wounds, and by incontinence of urine. The patient died a month after the operation. The post-mortem examination showed the lesions usually met with in tabes, but nothing to indicate a recent myelitis.

Weltrubski‡ stretched both sciatic nerves in a patient suffering from tabes with cystitis. The operation was followed by an aggravation of the motor and sensory troubles and by purulent nephritis. The patient died on the thirtieth day after the operation. A post-mortem examination showed a recent submeningeal hæmorrhage with a subjacent localized myelitis.

Lamarre.§—A man, aged sixty-six, healthy and strong, who had always enjoyed good health, in the beginning of 1879 noticed severe pain in the lumbar region. On the 12th of June there was found to be excessive reflex action, followed by spasmodic contraction of the limbs for several minutes at a time. There was wasting of both lower limbs; there was no fever and but little appetite. He had been unable to sleep, and suffered much pain. He was treated by chloral, morphia, and various other medicines, which relieved him for a time, but produced no permanent good effects. On the 12th of July it was decided to stretch the left sciatic nerve. The operation was done without chloroform, and presented nothing worthy of notice. It was followed by almost immediate cessation of the pain. The patient slept, and on the following day said that he felt quite well except for some tingling and numbness in the leg and foot. Without being

* Quoted by Tarnowski, *Archiv. de Neurol.*, July 1885.

† *Ibid.*

‡ *Ibid.*

§ *Revue de Chirurgie*, 1881, p. 493.

paralysed, the left lower extremity was not under the full control of the patient, and tendon reflex was less well marked than in the normal state. Sensations of touch, pain, and temperature were normal. On the 2nd of August, without apparent cause, the pain returned with great intensity. On the 4th the left sciatic nerve was stretched. Immediately afterwards there was great relief from the pain, and he slept well the following night. There was even more tingling in the limb than on the first occasion, and more diminution of muscular power without complete paralysis. Until the 8th the patient went on satisfactorily, but on that day a lancinating pain was felt a little above the incision. The skin was hot, and poultices were applied. On the 10th an incision was made in this situation, and pus was evacuated. On the 13th pains recurred very violently in the lumbar region, and on the 19th the patient died without having shown any symptoms of blood-poisoning. No post-mortem examination was permitted.

*Westphal.**—A man, aged thirty-one years, who suffered from a progressive loss of power of the lower extremities associated with spastic contraction, irritability, exaggerated knee reflex, and disturbances of sensation, was treated by stretching the right crural nerve. The muscular stiffness and knee reflex disappeared, while incontinence of urine and fæces, cystitis, and bed-sores made their appearance. These symptoms increased in severity, and after an intercurrent, right-sided hemiplegia, death occurred some weeks after the operation. The post-mortem examination showed a circumscribed degeneration of the brain, pons, and medulla, with diffused softening of the dorsal portion of the spinal cord and multiple points of degeneration in the right half of the lumbar cord. The diffused spinal degeneration was believed to be in consequence of the stretching of the crural nerve.

In another case recorded by Westphal,† death ensued from spinal meningitis after the operation of stretching the brachial plexus.

There would thus appear to be eleven cases on record in which death from lesion of the spinal cord seemed to be directly due to the nerve-stretching.

But not only may such troubles supervene after the operation preceded by incision, they may also result from the so-called bloodless system of stretching.

* *Centralblatt für die Med. Wissen.*, Dec. 1, 1883.

† *Loc cit.*

*Braun** records a case under Professor Prubram of Prague, in which a young man with long-standing rheumatism of the hips and knees was subjected to forcible movements of the limbs with the view of breaking down adhesions. Next day the patient died. A post-mortem examination showed numerous hæmorrhages along the sciatic nerve, and upon the dura and pia mater as far as the cervical region.

Gussenbauer† records a similar case in which, after precisely similar treatment, death ensued in nine hours.

There are thus in all thirteen cases of death after nerve-stretching directly due to injury to the spinal cord, for even where a post-mortem examination did not demonstrate the lesion, the symptoms pointed to it in an almost unmistakable manner.

I have no doubt that other cases have occurred, but do not think they can be numerous, and, whilst I should not look upon the operation as one free from danger, nor should lightly recommend it in trifling cases, yet I do not think that the mortality is sufficiently high to deter a surgeon from the performance of nerve-stretching in cases where the patient suffered seriously either from pain or other trouble.

It is to be noted that several of the deaths occurred in cases where several nerves were stretched at one operation, and therefore, as a matter of precaution, I should advise that an interval should elapse between the stretching of any two large nerves.

* *Prag. Med. Woch.*, Nos. 17, 18, 19, 1882.

† *Central. für Chir.*, Jan. 28, 1882.

CHAPTER XXII.

THE CLINICAL APPLICATION OF THE OPERATION OF NERVE-STRETCHING.

THE clinical history of nerve-stretching may be said to date from 1872—the year in which Nussbaum's and Billroth's cases were recorded.

The case recorded by Billroth* is generally, though erroneously, described as being the first in which the operation of nerve-stretching was practised. Such is not the fact, for if the author's own account be consulted, it will be found that the sciatic nerve was not stretched at all, but merely exposed and examined. The patient had been suffering from sciatic pains following a fall on the gluteal region, but after the operation the pain entirely disappeared.

The case by Nussbaum† must therefore be considered as the first in which the operation in question was practised, for this surgeon definitely planned and carried out the operation of nerve-stretching, and did not merely expose the nerve by chance. The patient was a soldier, who had received a severe blow from the butt-end of a rifle on the root of the neck on the left side. An abscess formed and was opened, but the muscles of the arm and hand, as well as those of the chest, became affected with painful spasms, and the skin of the back of the forearm anæsthetic. All these symptoms were entirely cured by stretching the nerves which form the brachial plexus.

Nussbaum also recorded another case in which a girl who suffered from a diseased elbow-joint had painful contractions of the ring and little fingers. The joint was excised, and during the operation the nerve was found enclosed in inflammatory tissue, from which it was freed. The contraction of the fingers ceased after the operation.

* *Archiv. für Klin. Chir. von Langenbeck*, 1872, Band xiii.

† *Deut. Zeit. für Chir.*, 1872, vol. i. p. 450.

Very shortly after Nussbaum's cases were recorded, Gardner* described a case in which he had stretched the brachial plexus on account of wasting and contraction of the arm and forearm in a case of hemiplegia accompanied by pain. The latter symptom was relieved by operation, but the patient died on the thirteenth day from hæmorrhage from the jugular vein.

Patruban† then recorded a case in which he had cured severe sciatica by stretching the sciatic nerve, and Vogt‡ followed by detailing another successful result in a patient whose ulnar nerve had been compressed in a cicatrix.

In 1875 Nussbaum§ stretched the tibial and peroneal nerves in a patient who suffered from epileptic fits with an aura commencing in the foot. The fits ceased.

In the same year Callender|| recorded the first performance of the operation in England, the patient being a young man who suffered from severe neuralgia of a stump.

In 1876 Nussbaum¶ cured clonic but painless contraction of the lower extremities in a case of paraplegia.

In the same year Vogt** stretched the brachial plexus in a patient suffering from tetanus. The patient recovered.

Petersen†† then described the case of a man who after a severe wound of the leg suffered great pain on the slightest movement of the limb, with extreme sensitiveness of the skin over the posterior tibial nerve. This nerve was stretched, and the patient completely cured.

In 1877 Vogt‡‡ recorded the first application of the operation of nerve-stretching to the cure of facial neuralgia. The inferior dental was the nerve operated upon, and a complete cure resulted.

After 1877 the operations for nerve-stretching became more numerous, and in the following year the operation was applied to the cure of spasms of the sterno-mastoid and of the facial muscles.

In 1879 Langenbuch recorded a case of tabes dorsalis in which the operation of nerve-stretching appeared to have given much relief.

In the following year Esmarch and Erlenmeyer performed the operation with similar results in other cases of the same disease.

In 1881 Dr. James Wallace recorded, in the *Indian Medical*

* *Deut. Zeit. für Chir.*, 1872, vol. i. p. 462.

† *Centra'. für Med. Wissen.*, 1873, p. 254.

‡ *Berlin. Klin. Woch.*, 1874, p. 22.

§ *Die Chir. Klin. in München*, 1875.

|| *Lancet*, June 1875.

¶ *Klin. Mitheil. München*, 1876.

** *Central. für Chir.*, 1876, No. 40.

†† *Ibid.*, 1876, No. 49.

‡‡ *Die Nervenlehre*.

Gazette, the first application of nerve-stretching to anæsthetic leprosy. In two cases there was great relief to pain.

Such is a very brief sketch of the advance of nerve-stretching as a therapeutic means. At different periods of its advance the successes and failures of the operation have been summarized by various authors. To some of their works I have already alluded, and if further details of the collections made in different countries are required, I would mention the following amongst others as worthy of perusal:—

1. Blum : *Archives Générales de Médecine*, 1878, vol. i. p. 22.
2. Chauvel : *Archives Générales de Médecine*, 1881, vol. vii. p. 707.
3. Fenger and Lee : *Journal of Nervous and Mental Disease*, New York, April 1881.
4. Artaud and Gilson : *Revue de Chirurgie*, 1882, p. 134.
5. Chandler : *New York Medical Record*, Sept. 2, 1882.
6. Nocht : *Centralblatt für Chirurgie*, Nov. 6, 1882.
7. Omboni : *Annali Universali di Med. e Chir.*, 1883.

To many of these I am indebted for much valuable information, and to them I would refer for statistical tables of cases and results. Some of the latter I shall venture to quote in considering the value of the operation of nerve-stretching in the various diseased conditions in which it has been applied. Since Omboni's statistics there have been many more cases published, but the operation is now so frequently performed that by far the larger bulk of the cases are not reported.

This is the natural fate of any operation which becomes popular, and, as a result, the published cases no longer afford a fair indication of the merits or demerits of the procedure. I have therefore decided against the advisability of adding a table of more recent statistics which, in my opinion, would probably be of a misleading nature.

I shall now proceed to discuss shortly the various conditions for which the operation of nerve-stretching has been performed, and endeavour to gauge its utility in each. For this purpose I shall quote such cases as appear to me to have a direct bearing upon the subject, and will only point out that on account of their great number it is evidently neither advisable nor necessary that I should endeavour to deal with all.

Nerve-stretching in Tabes Dorsalis.—Of the utility of the operation of nerve-stretching in cases of tabes dorsalis there has been, and still is, the greatest diversity of opinion.

In 1882 Dr. Chandler collected and analysed 57 cases. "In 16 of these the improvement was so decided and persistent that some of them have been reported in other papers as cured. . . . Twenty-seven received only temporary benefit (a few days to a few weeks). In 13 cases there was no improvement. In one case the operation seemed to be the cause of increased suffering."

Langenbuch, at a meeting of the Medical Society of Berlin, expressed his opinion that tabes dorsalis was frequently of peripheral origin, that there was an ascending neuritis, and that nerve-stretching was often most beneficial.

Omboni, in his work already referred to, has collected 99 cases. Of these he says that two were cured, 35 were permanently benefited, 43 were temporarily improved, and eight died. Omboni, nevertheless, expresses his opinion that nerve-stretching should never be performed in cases of tabes, the dangers in his opinion being considerable, and the prospect of benefit relatively slight.

Chauvel,* in a more recent article on nerve-stretching, expresses his opinion that the benefits derived from the performance of this operation in cases of tabes dorsalis have been greatly exaggerated. He considers that it should but rarely be performed.

Westphal goes further, and says that although he has seen numerous cases operated upon, he has not only never seen any benefit, but has frequently seen the patients rendered distinctly worse.

A consideration of the recorded cases leaves no doubt in my mind that the operation occasionally affords relief, and that whilst in some the improvement is very transient, in others it is more permanent. In some cases the operation entirely fails to give the least benefit.

I believe that the cause of this variety of results is to be found in the fact that all the cases which present the symptoms of tabes dorsalis do not exhibit the same pathological lesions. It has been shown by Déjérine that in some cases of tabes, so called, the spinal cord is intact, whilst the nerves are diseased; in others—and these the majority—the spinal cord presents the typical lesions in the postero-lateral and postero-median columns. For my own part, I am inclined to think that various morbid conditions are at present classified under the common head of tabes, and these must be further differentiated before the diagnosis of any individual case can be considered accurate.

* *Archives Gén. de Méd.*, 1885, vol. clv. p. 715.

The importance of recognizing such a possibility is very manifest when we come to consider the value of nerve-stretching in the treatment of such cases. For it is evident that whilst the operation might benefit a peripheral lesion, it is less likely to relieve symptoms dependent upon a central lesion. A case recorded by Langenbuch* throws so much light upon this subject that I shall venture to quote the main facts:

A man, aged forty, was admitted into hospital suffering from symptoms of tabes dorsalis. There was anæsthesia of the feet, marked ataxic gait, incoördination of the upper extremities, constrictive or girdle pains, absence of patellar tendon reflex, and very severe shooting pains in the limbs, especially in the legs. On Sept. 13th the left sciatic nerve was stretched: it appeared abnormally red and swollen. The operation was followed by temporary paralysis of motion and sensation, but the pain was much lessened. Twelve days later the other sciatic and both crural nerves were stretched. As the result of these operations the patient was entirely, and apparently, permanently cured of the pains, anæsthesia and ataxy of the lower extremities, so that he was able to walk well and easily. The pains in the upper extremities continued, and for their relief it was proposed some months later to stretch the axillary nerves. The patient, however, died suddenly from chloroform narcosis before the operation was performed. The spinal cord was examined by Dr. Westphal, and was found to be quite normal. The condition of the peripheral nerves is not stated.

Here then we have a case which was actually recorded as a successful instance of nerve-stretching for the cure of tabes dorsalis. Yet the spinal cord was absolutely normal. It cannot be claimed that the natural state of the cord was the result of the nerve-stretching, for at the time of his death the patient still suffered from pains and incoördination of the upper extremities of an exactly similar nature to those for which the original operation had been undertaken. It is more than probable, in my opinion, that other instances of great benefit or of cure may bear a similar explanation, and I therefore repeat that, before we can duly estimate the real value of nerve-stretching in such cases, it is of prime necessity that the diagnosis of cases in which the spinal cord is itself the seat of disease shall be separated by an accurate diagnosis from others in which it is healthy.

The manner in which the operation acts is purely speculative.

* *Berlin. Klin. Woch.*, No. 48, 1879.

We cannot adequately explain the effect of nerve-stretching when we do not know the pathological condition for which the operation is performed. For my own part, I believe that the relief to pain is most probably due to the mechanical lesion of the sensory fibres, but it is quite possible that some beneficial effect may be produced upon the spinal ganglia or on the cord itself. Theoretically, however, stretching of the sciatic nerve ought to be the worst possible thing in cases of tabes, for, supposing the results of Tarnowski's experiments (already described) are correct, the operation is itself capable of producing exactly the same lesions in the spinal cord as are typical of tabes itself.

In those cases, however, in which the symptoms are dependent upon disease of the peripheral nerves it is not so difficult to understand that benefit may accrue. Where there is sclerosis the nerve-fibres may be freed from the connective tissue which compresses them; where there is atrophy, the increased vascularity may bring an increased supply of blood and restore the impaired nutrition; and where pain is due to disease of the nerve itself, the rupture of its fibres will give relief, at any rate for a time.

But taking the cases as they at present are known, and in the absence of a proper differential diagnosis, to what extent are we to expect benefit in any given case? The question is not easy to answer definitely, but some information is afforded by a careful study of recorded operations. In a very large number of these no benefit occurred, and in some the anæsthesia, the muscular weakness, and the vesical irritation were all increased, so that the patient was left in a worse condition than before treatment.

In another class of cases there was slight but temporary improvement. In a few there was permanent improvement, and in three or four a complete cure is claimed. Now it is a well-ascertained fact that the statistics of published cases are no real clue to the statistics of an operation which is frequently performed. There is a great and a natural tendency to publish cases where treatment has been successful, and to suppress those which have resulted in failure. I cannot doubt that this applies to the operation of nerve-stretching for tabes, and am therefore of opinion that in the larger proportion no benefit is to be looked for.

In those patients, however, who do obtain relief, it is the pain rather than the ataxy which is benefited, and I append here a few cases in illustration of what may be considered satisfactory results as far as relief to pain is concerned. In some of these

there was also noticed a return of sensation in areas previously anæsthetic :

*Johnson.**—The patient had suffered for twelve years from pains in the limbs. For three years he had noticed that he was unsteady on his legs. There was anæsthesia of the feet and absence of reflexes. There was partial anæsthesia of the legs and slight ataxy of the arms. He had occasional girdle pains and absence of pupil reflex. On April 24, 1881, the right sciatic nerve was stretched. Five weeks later there was much improvement in respect to the pains, which had to a considerable extent disappeared. There was no improvement in any of the other symptoms.

Cavafy.†—A man, aged forty-eight, was admitted into St. George's Hospital on Dec. 29, 1880. For three years and a half he had been gradually losing the strength of his legs, and especially co-ordinating power, so that he soon became unable to walk in the dark. He had had several epileptic fits. There were pains of a darting and shooting character in the legs, groins, and thighs. Occasionally he had constrictive pains round the waist. There were occasional attacks of sudden vomiting and epigastric pain. Ataxic gait was well marked. There was absence of reflex and partial loss of sensation in the legs and feet.

March 9th.—Left sciatic nerve stretched. The wound was long in healing. The effect of the operation on his pains was decidedly beneficial. They ceased entirely until April 2nd, when they reappeared in the left leg and thigh, but less severely, and only lasted a few days. He remained at the Convalescent Home until May 24th, and on the afternoon of that day he suddenly uttered a moaning cry, became unconscious, and had a series of epileptic fits. The fits chiefly affected the left side of the body. He then became comatose and died the same evening. Post-mortem examination showed that in the spinal cord there was a patch of opaque adherent membrane in the lower dorsal region, and the posterior columns were of a reddish grey tint. Microscopic section of the cord showed excessive degenerative

* *British Medical Journal*, 1881, vol. ii. p. 11.

† *Ibid.*, Dec. 10, 1881, p. 929.

changes most marked in the lumbar region. The postero-median and postero-external columns were in a state of advanced sclerosis, and the same changes were present in a lesser degree in the posterior part of the lateral column.

Marshall.—Nerve-stretching in Tabes.—Relief to Pain.*

A man, aged thirty-nine, had suffered from ataxy for three and a half years. In Feb. 1881, he was unable to stand without the support of two persons, and suffered from much pain in the hypogastrium. The right sciatic nerve was stretched both upwards and downwards, and the pain disappeared. The left sciatic was then operated on. Six weeks after the first operation he still required two people to support him upright, and was very weak, but the gait is said to have been better than before. No return of pain.

Johnston.†—Nerve-stretching in Tabes.—Relief to Pain and Anæsthesia.

A man, aged thirty-nine, had suffered from tabetic pains for twelve years and ataxy for three years. The sciatic nerve was stretched forcibly. Five weeks after the operation the pains were found to be not nearly so acute as before, and came on at longer intervals. Anæsthesia was somewhat diminished, but there was no improvement in ataxy.

Gillette.‡—Tabes Dorsalis.—Sciatic Nerve Stretched.—Improvement in Pains.

M., aged fifty-six, the subject of tabes dorsalis, had suffered for six years from lightning pains in all the limbs and from complete incoördination of the lower extremities; the pains recurred at least every two days. He had been confined to bed for eighteen months.

The left sciatic nerve was vigorously stretched, but no anæsthesia or paralysis was caused. During the five weeks following operation—*i.e.*, until the time at which the case was reported—there had been no return of the lightning pains in any of the limbs, but

* *British Medical Journal*, Dec. 17, 1881, p. 973.

† *Ibid.*

‡ *Bull. et Mém. de la Soc. de Chir. de Paris*, vol. vi. p. 717.

there had been two gastric crises of slight intensity, though not nearly so severe as those from which the patient formerly suffered. He was able to walk a few steps with assistance.

Langer.—Tabes Dorsalis.—Sciatic Nerve Stretched.—Transient Improvement in Pains.*

A lady, aged fifty-nine, who had suffered from slowly advancing tabes dorsalis for twenty years, had of late experienced extreme pains in the right leg. In order to relieve this the sciatic nerve was stretched. For three weeks the pains were not felt, but at that time they commenced to return, and in three months were as bad as formerly.

Esmarch.†—Tabes Dorsalis.—Stretching of Brachial Plexus. Relief to Pain.—Improvement.

In a discussion on a communication by Cr  d   on nerve-stretching, Esmarch mentioned that he had stretched the brachial plexus in the axilla in a case of tabes under the care of Prof. Quincke, with the result that pain and muscular inco  rdination disappeared, not only in the arm, which was the seat of operation, but also in the other limbs.

In the following cases the operation of nerve-stretching resulted in some benefit to the muscular system, with partial loss of ataxy and restoration of muscular power. Instances of this are rare; they are, however, sufficient to show that such improvement is possible.

Gillette.‡—Stretching of the Median and Ulnar Nerves for Tabes. Slight Improvement in Pains and Ataxy.

M., aged fifty, had suffered for fifteen years from tabetic pains in the upper extremities of daily occurrence. The median and ulnar nerves on the right side were stretched in the upper part of the arm. The operation was followed by a tingling sensation in the palm of the hand, but during the eight days that intervened between the operation and the report of the case there was no

* *Bull. et M  m. de la Soc. de Chir. de Paris*, 1883, p. 157.

† *Deutsche Med. Wochen.*, 1830, No. 19. ‡ *Soc. de Chir.* vol. vi. p. 717.

return of the lightning pains, and the incoördination of the lower extremities was so much improved that the patient was able to walk with the aid of a stick, instead of, as formerly, clinging to the beds in the ward.

Langenbuch.—Tabes Dorsalis.—Stretching of both Sciatics and Anterior Crural Nerves.—Improvement in Pains and Ataxy.*

A man, aged forty, had suffered for some months from symptoms of tabes dorsalis, including lightning pains in all the limbs, muscular incoördination of the lower extremities, diminution of sensation, constricting pains, and loss of tendon reflex. The chief pains were in the back of the left thigh and leg.

On Sept. 13th, Langenbuch stretched the left sciatic nerve under chloroform, with the result of causing a complete cessation of pain in the left lower extremity, and a transient paralysis of motion and sensation, which lasted a few days.

On Sept. 25, the right sciatic and both anterior crural nerves were stretched with similar results in each of the limbs, the pains disappearing and there being a transient paralysis. In addition, the muscular incoördination and loss of tactile sensibility in the feet were quite cured for the time. The patient died in an epileptic attack some months later.

*Debove.†—Tabes Dorsalis.—Stretching of one Sciatic Nerve.
Improvement in Pains and Ataxy.*

A man, aged fifty-six, was seized with lightning pains in the legs, in 1874. Six weeks later symptoms of muscular incoördination appeared, together with lightning pains in the arms. The pains continued and increased, and were followed by gastric crises and urinary troubles. The muscular incoördination increased to such an extent that the patient was absolutely confined to bed, all muscular sense being abolished, and the sense of touch much impaired. There was complete absence of tendon reflex. At the request of M. Debove the left sciatic nerve was stretched by M. Gillette, without chloroform, on Nov. 18th. The operation caused no paralysis. The day after the operation the patient

* *Berlin. Klin. Wochens.*, 1879, No. 48.

† *L'Union Méd.*, 1880, vol. xxx. p. 976.

complained of slight tingling pains in the lower extremities, but the lightning pains had altogether disappeared.

Nov. 20th.—Both muscular and tactile sensation had much improved, and but little incoördination remained.

26th.—The patient walked a few steps with assistance.

Dec. 1st.—There occurred a slight gastric crisis, which was infinitely less severe than any others from which he had suffered of late.

On Dec. 19th, when the case was reported, the patient's symptoms were all very greatly diminished, and he could walk with assistance. Tendon reflex remained absent throughout.

The improvement in this case was testified to by MM. Charcot and Bouchard.

Langenbuch.—Nerve-stretching in Tabes Dorsalis.—Great Improvement.—Relief of Pain and Ataxy.*

A woman, aged thirty, had for six years noticed absolute anæsthesia of the feet and legs, with lightning pains and gastric crises. The case was one of tabes dorsalis. The sciatic nerve was stretched, with the result that there was a general return of sensation and an almost entire disappearance of the ataxic symptoms.

Davidson.†—Both Sciatics Stretched.—Relief of Pain and Ataxy.

A joiner, aged thirty-six, had suffered from tabes for two years, with attacks of bilious vomiting, headache, and hazy vision, and had had shooting pains in the legs for one year, with characteristic ataxia. The patellar tendon reflex was absent. Both sciatics were stretched with an extension of 40 lb. The wounds healed slowly. At the end of three weeks there was improvement in coördination and a slight return of patellar reflex. There were no recurrences of lightning pains and gastric attacks, and at the end of two months the patient could walk fairly well, the patellar reflex being still more evident.

* Congress of German Surgeons, 1881: *Revue de Chirurgie*, 1881, p. 751.

† *Lancet*, vol. ii. 1881, p. 389.

Benedict.—Nerve-stretching in Tabes.—Relief of Pain and Ataxy.*

In two cases it is said that the pains disappeared, after the stretching of one sciatic, not only in both lower extremities, but over the whole body. Constrictive pains also subsided, and anæsthesia was improved. In one patient, who had long suffered from paralysis of the bladder, this symptom disappeared. The ataxy was markedly improved, especially by the double operation, one patient who could only walk with two sticks being afterwards able to walk without any support, and to turn easily.

It does not appear to me to be necessary to quote at length the numerous recorded cases in which the operation of nerve-stretching has failed to give relief to patients suffering from tabes. Suffice it to say, that in their clinical symptoms they do not apparently differ from those in which benefit has been derived from nerve-stretching.

In giving a prognosis as to the probable benefits to be derived from the performance of the operation in question in any given case of tabes, I should certainly not feel justified in holding out any prospects of a complete or permanent cure. On the other hand, I should say that in all probability no good would ensue, and that any improvement would probably be transient. The rarity with which any material good to the ataxic symptoms follows nerve-stretching would prevent me from submitting any patient to operation and its consequent risks with this end alone in view.

The prospects of affording relief to the pains in the limbs are certainly more encouraging, and if the patient really suffers very greatly, I think that the chances of relief are sufficient to justify the performance of nerve-stretching, always provided that it be clearly understood that failure is more probable than success, and that relief is more likely to be transient than permanent.

In the case of the lower extremity, I should not expose the sciatic nerve until I had given the bloodless method of stretching a fair trial.

Nerve-stretching in Diseases of the Brain and Spinal Cord.—The results of the treatment of diseases of the brain and spinal cord by nerve-stretching are certainly not encouraging. I

* *British Medical Journal*, Dec. 17, 1881, p. 973.

believe that a single case of permanent cure is yet recorded. In some cases—and these are few—there was noted a considerable improvement; in others, a transient improvement; and, in the great majority, even of the published cases, no good resulted from the operation.

I do not, therefore, propose to deal at length with the subject of disease of the cerebro-spinal centres in relation to the operation of nerve-stretching, but shall touch briefly on the various morbid conditions for which the nerves have been stretched.

Nerve-stretching in Myelitis.—A case of spasm, with paralysis, consequent upon an injury to the spine, in a boy, aged eleven, is recorded by Nussbaum.* Both sciatic and crurals were stretched, with the result that the paralysis persisted, but the spasms ceased.

In another case of the same nature, by Riedel,† after a similar operation, there was a return of sensation in parts previously anæsthetic and an improvement in locomotion.

In both these cases the symptoms are considered to have been due to a myelitis set up by the injury. It is, however, quite possible that they really were due to the compression of the nerves themselves by displaced bone, or by callus and inflammatory thickening.

In a case by Czerney,‡ the operation of stretching both sciatics was performed for the relief of symptoms of compression of the cord in a patient who suffered from angular curvature of the spine. Not only was there no improvement, but the patient's troubles were aggravated.

Dontrélepon§ records a case of a man, aged thirty-one, who suffered from chronic myelitis, with paraplegia, anæsthesia, loss of knee-jerks, and painful micturition. Both sciatics and both crural nerves were stretched, with the result that sensation returned and the urinary troubles were improved.

The following disappointing case is reported by Dr. Morton :

Morton.||—Great but transient Improvement in a Case of Chronic Transverse Myelitis, treated by Nerve-stretching.

The patient was a man, aged sixty-four. In 1864 he first

* Quoted by Artaud and Gilson, *op. cit.* ; and by Chandler, *loc. cit.*

† *Ibid.* ‡ Quoted by Chandler § Quoted by Artaud and Gilson.

|| *New York Medical Record*, vol. xxi. p. 240.

noticed a tingling sensation in his feet. This extended to the legs. During the last two years had had twitching in the legs; loss of sensation; sensation of contraction around the waist; wasting of the muscles; incontinence of urine; and great difficulty of locomotion. When first seen, there were exaggerated reflexes; a sensation of walking on soft ground, ataxic gait, coldness, bluish colour of the legs, and atrophy of muscles; no pain in his legs. On Aug. 4, 1881, the right sciatic nerve was stretched by Dr. Osborn with excellent results. On Sept. 18th, Dr. Morton stretched the left sciatic. The operation was performed without anæsthesia. Cutaneous sensation returned immediately upon the stretching. The legs, five minutes previously insensible to the cut of a knife, were now sensible to the slightest prick of a pin. During the operation the patient located the pain of the incision and handling of the nerve to the region of the anus. After stretching, he located painful sensations correctly. An immediate consequence of the return of sensation was a return of the knowledge of the relation of the soles of his feet to the ground, whilst the power of motion seemed, as it were, miraculously restored. One month later the patient was much improved. On Jan. 27, 1882, there was very little benefit remaining from the operation. Anæsthesia was not quite so complete as before, but the other symptoms were nearly as prominent as previously.

I do not know of any other cases of myelitis treated by nerve-stretching, with the exception of one by Massing,* in which some improvement of sensation followed the operation; and do not consider that the number of recorded cases is sufficient to allow of any definite conclusions being drawn.

Spasmodic Spinal Paralysis.—I have only seen one case of spasmodic spinal paralysis treated by nerve-stretching. It is fully reported by Mr. Langton.† The patient was a man, aged twenty-five. The right leg and thigh were constantly affected with the spasmodic movements typical of the disease in question. The right arm was also affected, though to a slight extent.

The right sciatic nerve was stretched, but no improvement ensued until, after an interval of several weeks, the patient was placed under treatment by belladonna. Some months later, he

* Quoted by Chandler.

† *St. Bartholomew's Hospital Reports*, vol. xvii. p. 190.

reported himself as greatly relieved, but I do not think that there is any evidence that the improvement was due to the nerve-stretching.

The following cases will give some idea of the possible benefits of nerve-stretching in such cases :

Morton.—Nerve-stretching for Spastic Spinal Paralysis.
Great Improvement.*

A man, aged fifty, ten months before coming under notice, had pains in the joints which he thought were due to rheumatism. All the bones of his body ached at the same time. He had twitching and cramps in the legs and arms, and interlocking of the heels in walking. There soon followed a feeling of numbness and tingling in the hands and feet, together with much loss of power. During the last four months before he came under notice, the general numbness and tingling had ceased, but the loss of power had decidedly increased. His gait was slow and shambling, and he had to use a cane. When examined in April 1881, all the leg muscles were in a spastic condition, and tendon reflexes exaggerated. Any attempt at positive motion was met by involuntary muscular resistance, which had to be slowly overcome, and such an attempt provoked at the same time violent shaking of the limb. An operation was performed on June 16th, and the right sciatic nerve was stretched. The nerve presented nothing abnormal in its appearance. The stretching was continued about five minutes. The wound was closed by sutures, and the patient was able to walk immediately afterwards. The wound healed rapidly. The patient's symptoms were almost immediately relieved, and on the sixth day he walked over a mile. He improved till about August, when his left leg began to get bad again. On October 11th, the left sciatic was stretched. He steadily improved, and on Jan. 23, 1882, had only a slight weakness in the left knee and ankle, with slight exaggeration of tendon reflexes.

*Thiersch.†—Spastic Spinal Paralysis.—Sciatic Nerve Stretched.
Slight and transient Improvement.*

The patient was a man, thirty-five years old, with spastic spinal

* *New York Medical Record*, vol. xxi. p. 240.

† *Boston Medical and Surgical Journal*, March 2, 1882.

paralysis of six years' standing, following an attack of typhoid fever. Both sciatic nerves were stretched, with the result that the patellar reflex was much lessened, having been previously excessive. Two days later, reflexes had entirely disappeared in the lower extremities. Thirteen days after the operation, patellar reflex was again present, and in the left leg stronger than normal. Before the patient was discharged, he was in exactly the same condition as before the operation.

Westphal.—At a discussion on nerve-stretching of the Medical Society of Berlin, Westphal stated that the stretching of the crural nerve had been practised on a patient who suffered from spasmodic spinal paralysis. The result was, that the spasmodic paralysis was changed into a passive paralysis, and that on both sides, instead of one as previously. At the same time there appeared a complete paralysis of the bladder and of the rectum, which had not existed previously. In addition, an ulcer, apparently of trophic origin, formed on the limb. When the patient was cured of the immediate results of the operation, there developed a contraction of the flexors of the limbs, which entirely prevented him from walking, besides which the reflex excitability was considerably exaggerated. All these symptoms appeared to point to transverse myelitis. The patient died three years later, and there was found in the lumbar region of the spinal cord a small spot of softening.

Nerve-stretching in Paralysis Agitans.—The cases of paralysis agitans treated by nerve-stretching are as yet few, and are scarcely sufficiently encouraging to cause their number to be very greatly increased.

Thus Westphal, in the discussion previously alluded to, said that he knew of three cases treated by this operation. In the first, the trouble had reappeared some days later; in the second, the principal result had been a paralysis of the parts supplied by the musculo-spiral nerve. The third patient had died six days after the operation, and at the post-mortem examination there was found suppurative cerebral meningitis.

These results are not encouraging, but the following case by Morton shows a little brighter side, though to what extent the patient was benefited is not quite clear, and the description of the condition of the sciatic nerve throws some doubt on the true nature of the case. Possibly it was a peripheral neuritis.

Morton.—Paralysis Agitans.—Nerve-stretching.—Improvement.*

The patient was a man, aged forty-three, whose present trouble began in 1875 with shaking in the left arm and leg. In 1877 the same symptoms appeared in the right side. In 1879 the whole body except the head began to be comparatively rigid, and difficulty in walking increased. In the spring of 1881 all his symptoms had become more pronounced. He could not dress himself or feed himself. Walking was difficult and clumsy. There was no apparent cause. He had been treated by galvanism and various medicines, but continued to grow steadily worse. On Oct. 18th the sciatic nerve was stretched. It was found to be hard, firm, stiff, and unyielding, and was of a dirty yellowish-brown colour. Apparently it was in a condition of sclerosis. On recovering from the ether the patient had very imperfect use of his leg, the toes drooped, the foot swung inward, and he could not advance or draw back the leg. Sensation was nearly abolished. The wound suppurated for several days and the patient was worse; then the paralysis began to mend. On Nov. 20th the walking had greatly improved, the general rigidity was nearly gone. Tremor was less severe, with longer periods of rest. On Feb. 1, 1882, he was reported a great deal better than before the operation.

Nerve-stretching for Sclerosis of the Nervous Centres.—A case of nerve-stretching in a patient suffering from lateral sclerosis is recorded by Southam in the *Lancet* for 1881.

The operation was undertaken for the relief of pain, and the result was so far satisfactory, that for six weeks after the nerve-stretching the patient remained free from pain. The other symptoms were not benefited, and it is of course questionable whether the relief was more than could be accounted for by the mechanical lesion of the nerve-fibres at the time of operation.

Of the two next cases by McCulloch, one appears to have benefited rather by anti-syphilitic remedies than by operation; in the other, the nerve-stretching seems to have given relief.

McCulloch.†—Cases of Nerve-stretching for Multiple Spinal Sclerosis.

A man, aged twenty, who a year previously had had syphilis, was seized ten months ago with retention of urine and paraplegia.

* *New York Medical Record*, vol. xxi. p. 240.

† *Lancet*, Sept. 5, 1885

Since then he has never been able to stand or walk, and on the slightest attempt to do so is seized with violent tremors. On admission to hospital he had very violent tremors and incoördination of the muscles, especially of the legs, but also slightly of the body and arms. Tendon reflex and ankle clonus much exaggerated. He had incontinence of urine. Both sciatics were stretched on May 23rd, with immediate improvement of sensation and diminution of tremors.

July 25th.—The patient can now stand and even walk with assistance, but this improvement was not noted until after treatment by iodide of potassium and mercury. There was no immediate benefit from operation.

McCulloch.—Nerve-stretching for Multiple Cerebro-spinal Sclerosis.*

The patient was a man, aged thirty-five, whose illness had been in progress for two years. There was general shaking, and the patient could scarcely walk. There was no anæsthesia; there was marked ankle clonus, and all the reflexes were exaggerated.

March 26, 1885.—The sciatic nerve was stretched.

29th.—The shaking is less; the wound has healed soundly.

May 19th.—Very great general improvement. There are slight tremors of the head when he is excited, but no other abnormal symptoms.

Nerve-stretching for Athetosis.—Considering that in cases of athetosis there is generally some imperfection in the brain, it does not seem probable that nerve-stretching would be at all likely to give relief to patients suffering from this malady, and I do not think that the two following instances by American surgeons afford much encouragement.

In each, such improvement as was noted could readily be accounted for by the mechanical effects of the operation on the nerve-trunk. No permanent benefit is recorded.

Morton.†—Athetosis.—Nerve-stretching.—Very slight Improvement.

At the age of three, it was noticed that the right leg of the patient gave way, causing him to fall. He had no convulsions or loss of consciousness. Until eleven years of age he was very lame, and then walked better. Three months after the right leg was first

* *Lancet*, Sept. 5, 1885.

† *New York Medical Record*, vol. xxi. p. 240.

affected the right hand began to show peculiar movements. It would unintentionally close on objects and hold them fast, then the hand and fingers began to twist and work, particularly when he attempted any movement. This hand, as far as he recollects, has never been better or worse up to the time that he was seen in 1881. On Nov. 16th the ulnar and median nerves were stretched. On the 25th the hand was quiet for the first time in the patient's memory.

Jan. 25, 1882.—All continuous and compound movements are now abolished, but there is at times a very slight twitching of the thumb. The position of the fingers is that of easy and natural flexion. Some numbness of the hand exists. The patient says it is a great deal less trouble to him than formerly, and in a much preferable condition.

Hammond.—Athetosis.—Relief by Nerve-stretching.*

This operation was performed upon the median nerve on May 27, 1887, with the result that the patient could open and shut his hand at will, and take off his coat and write his name, things which he had been unable to do for twenty-three years. The hand was also quiet during the night, as also was the leg, and only two epileptic seizures had occurred since the operation. The case was recorded three weeks after the nerve was stretched.

Nerve-stretching for Tetanus.—From the accounts of cases by Vogt, recorded in 1877, it was believed by many that at last a treatment for tetanus had been discovered which gave better prospects of relief than any which had preceded it. But, like many other remedies, nerve-stretching has not confirmed the hopes which it excited.

I do not propose to detail the cases of tetanus treated by nerve-stretching. Some have recovered. The vast majority have died. Even in published cases recoveries are only about 12 per cent. of the total, and there can be little doubt that, whilst most of the successful cases have been published, those in which the operation has failed have not all come to light.

A careful reading of the published cases will, I believe, lead any impartial observer to the conclusion that in none of them is there clear evidence that the tetanus was cured by the operation. I wish that I could think they held out any such hope, and will venture to point out very briefly my reasons for thinking they do not do so.

* *New York Medical Record*, vol. xxii. p. 21.

First. All the cases were essentially of the chronic type, and it must be borne in mind that the death-rate in such is infinitely lower than in the acute cases.

Secondly. In almost all, medicinal treatment was adopted, both before and after the operation.

Thirdly. In most of the cases, the tetanus continued for several days after the nerve-stretching.

I do not believe that a single case has been yet recorded in which it could certainly be said that the operation has saved a patient's life. What is more, in several of these cases it is noted that the spasms were worse after operation than before.

For my own part, I would not perform nerve-stretching for tetanus, as I believe it is of no use, and, with the possibility of doing direct injury to the patient before my mind, I would certainly dissuade others from its performance.

Nerve-stretching and Neurotomy for Epilepsy.—I have already, when dealing with the complication of nerve injuries, shown that epilepsy may follow on a wound of a nerve, and to that chapter I would refer for further evidence.

Not only, however, has epilepsy of a traumatic origin been treated by operations on the nerves, but idiopathic epilepsy, with a definite aura commencing in some peripheral part, has been similarly treated. Nerve-stretching and neurotomy have each been tried, and the following cases afford some evidence of the success attending such treatment.

Nerve-stretching and Neurectomy for Traumatic Epilepsy.

C. McS., aged forty-three, was admitted into St. Bartholomew's Hospital in Oct. 1880, having received a gunshot wound of the leg some months previously. Since the wound healed he has become subject to epileptic seizures. There is no definite aura extending from the leg, but the limb is painful. An examination shows some scars on the outer side of the leg, and in several places shot can be felt close to the situation of the musculo-cutaneous nerve. Whilst in hospital the patient had several fits of a typical epileptic nature, but of short duration. Thinking that the patient might be improved by operation, Mr. Holden cut down upon and removed three inches of the musculo-cutaneous nerve, as well as some shot which lay beside it. For some days after the operation the fits continued. Then they

gradually subsided, and finally entirely ceased before the patient left the hospital. For three years and a quarter he remained well, and then returned, on April 17, 1884, saying that until one month ago he had not been subject to any of his former fits, but now has frequent epileptiform attacks. They occurred sometimes as frequently as twenty times a day. There is a shot near the old scar in the leg.

29th.—Shot removed. The fits ceased for two days, when the patient was discharged.

July 1st.—Readmitted. The fits have returned, and for the past three weeks have been very violent. They are worse during exercise.

9th.—Sciatic nerve stretched.

10th.—Partial anæsthesia of the foot and leg.

14th.—Extreme hyperæsthesia of the buttock.

25th.—Suppuration along the course of the nerve up to the sciatic notch. Abscess freely opened. He was discharged, there having been no fits since the operation.

Aug. 5, 1885.—Returned to the hospital. He has now as many as ten or twelve fits a day. They returned a week or two ago.

Panas.—Nerve-stretching in the treatment of Traumatic Neuroma, with Neuralgia and Epilepsy.—Cure.*

The patient, a man aged forty, had four years previously received a cut from a knife which pierced the middle of the thigh immediately behind the femur. Since then there had been paralysis of the muscles of the leg and of the foot. Sensation of the skin of a corresponding area had disappeared. The paralysed limb had become the seat of lancinating pain and of the phenomena of spinal epilepsy. The sufferings had become so intolerable that the patient wished to have the leg amputated. On examination there was found to be paralysis and atrophy of the muscles of the limb and of the foot, which latter was in the position of equinovarus. The skin was blue and cold, there was cutaneous anæsthesia of the foot except on the outer part of the dorsum. On the outer part of the leg there was hyperæsthesia, especially about the external malleolus, at the middle of the leg, and at the level of the head of the fibula. Pressure upon this last point provoked severe pain and the phenomena of spinal epilepsy. Convulsions of the

* *Revue de Chirurgie*, 1882, p. 425.

limb were produced by the least movement of the foot. There was habitual trembling localized to the left leg, but it occasionally extended to the right leg. On the 2nd of July, 1881, the sciatic nerve was stretched. When exposed there was found to be a fusiform neuroma five centimetres in length at the seat of the original injury. On the 3rd, the pains had ceased and the wound had almost healed. The cure was complete and permanent for at any rate four months after the operation, there being no more pain or convulsions, and the hyperæsthesia had disappeared. The patient walked well.

Lande.—Neurotomy for Epilepsy following a Wound of the Median Nerve.*

A man, aged twenty-two, received a bullet wound of the forearm in Oct. 1870. The median nerve was wounded and the patient suffered great pain. The fingers immediately were doubled into the palm and remained contracted for two days. A year later, the wound being not yet healed, he was suddenly seized with severe pain in the hand, followed by an epileptic seizure in which he bit his tongue. From this time he became liable to similar seizures at intervals of a few days. In July 1872, he first came under Dr. Lande's care. At that time there was hyperæsthesia of the palm of the hand. The fits were preceded by severe pain and clutching movements for several minutes. Two centimetres of the median nerve were excised, and from that time forwards the fits ceased. The patient was seen nine months after the operation.

Morton.†—Reflex Epilepsy.—Nerve-stretching of Brachial Plexus. Improvement (?)

The patient, a man aged forty, had for ten years been subject to numerous daily attacks of spasm, which occurred mostly in bed between three and six A.M., without any loss of consciousness. An aura always existed. The main peculiarity of the attack was that it could be induced at the will of the patient or physician by touching various points of what appeared to be a true epileptic zone. A touch on the right side of the neck or the shoulder often brought on an attack. He was treated with various medicines and with electricity with temporary good results, but as he began to get worse

* Quoted by Létievant. † *New York Medical Record*, vol. xxi. p. 240.

the brachial plexus was stretched in the axilla. The result of this case could not be certainly stated, as the operation had been but recently performed. There appeared, however, to be some improvement.

Gillette.—Nerve-stretching for Epilepsy.*

The patient had been subject to epilepsy from youth. The median and ulnar nerves were stretched in the upper part of the arm, with the result that the fits diminished greatly in number and in intensity. In addition, the pains in the arms which had always preceded the fits completely disappeared, and the period of unconsciousness after an attack was much shortened.

Nussbaum.†—A man, aged twenty-one, who suffered from talipes equino-varus, had been subject to epileptic attacks for nine years. Latterly these attacks had become more frequent, and occurred as often as six times a day. Each seizure was preceded by a pain, commencing in the deformed foot and passing up the back of the limb. The internal and external popliteal nerves were stretched, with the result that the fits entirely ceased.

Czerney ‡ records a case of epilepsy, with an aura, starting in the region of the ulnar nerve. The latter was stretched, but without causing any improvement.

Such cases as the above certainly offer some encouragement to the operative treatment of reflex epilepsy. I am, however, of the opinion that in idiopathic cases the failures will probably greatly exceed the successes. It is well known that even after amputation of the part from whence the aura originated, the fits have not diminished in the least degree. Nevertheless, in any case of a definitely localized aura, I would certainly advise that a trial should be given to nerve-stretching. I would not recommend neurotomy, for all the benefits it offers can be supplied by nerve-stretching, in which, as I have previously shown, the nerve-fibres can be completely divided within the nerve-sheath, if the stretching be sufficiently vigorous.

* *Le Progrès Médical*, 1881, vol. ix. p. 100.

† Quoted by Blum, *loc. cit.*

‡ Quoted by Fenger and Lee.

Much more good is likely to result from similar treatment in cases of traumatic origin, and, where there is any definite nerve injury, a good prognosis will, I believe, be justified. But in such cases the nerve ought not simply to be stretched; it should be exposed at the seat of injury, and, if surrounded by scar tissue, should be freed. If irritated by any foreign body this should be removed. No pains should be spared to discover and remove any abnormal local condition.

Especially in cases of motor or mixed nerves, I should always prefer nerve-stretching to neurotomy or neurectomy; and if, after a time, the epilepsy recurred, I would repeat the operation before proceeding to perform neurotomy.

Nerve-stretching for Local Spasm.—The operation of nerve-stretching has been performed in various parts of the body for local spasms, some of traumatic origin, others idiopathic.

It is not advisable to consider all these operations together, for they differ much amongst themselves, and I therefore prefer to separate them into different classes according to the nerve affected and to the cause of the spasm.

Nerve-stretching for Facial Tic.—Cases of facial spasm, so-called "facial tic," are not uncommon in mild forms. Thus, blepharo-spasm is tolerably frequent, and is often transient. For these milder forms of spasm operative interference can but seldom be required.

There are, however, other cases at once more severe and more rare, in which the whole of the muscles of one side of the face become affected, and in which, therefore, operations are more likely to be necessary. The most common exciting cause is sudden fright, grief, or mental worry, especially in patients in a weak state of health. In no case should the surgeon be in a hurry to operate, for the attack may pass off, or may yield to internal remedies or to galvanism, and these should always be given a thorough trial.

In no case, in my opinion, should neurotomy or neurectomy be performed. Stretching of the facial nerve is the only operation likely to be beneficial and to leave the patient without permanent paralysis.

The operation for exposing the facial nerve has already been described. The results of stretching this nerve for facial tic have not been altogether satisfactory, even judging by the published cases.

The operation has been performed in twenty-one cases, which are tabulated by Keen in an excellent paper in the July number of the *Annals of Surgery* for 1886; and fourteen of them are also tabulated by Godlee, in vol. xvi. of the *Transactions of the Clinical Society of London*. To these authors I am indebted for references to the literature of an operation which has been performed in England by Godlee and by Southam, as well as by various surgeons in America and on the Continent.

The following are brief notes of the cases :

Baum.—Stretching of the Facial Nerve for Convulsive Tic.*

The patient was a woman, aged thirty-five, of delicate constitution. Six years previously she had a sort of epileptic seizure, after which the twitching of the face began, affecting the eyelid first, and spreading to the rest of the left side of the face. At first it lasted for one month, then intermitted for two, and then became chronic. The right side of the mouth was occasionally affected.

The facial nerve was stretched on July 20, 1878. There was some paralysis, but it disappeared in half an hour. Up to nine months later there was no return of spasm; then it recurred slightly. Two years after operation there was slight spasm, but not nearly as bad as previously.

Bernhardt.†—Stretching of the Facial Nerve for Convulsive Tic.

The patient was a man, aged thirty-six, who first had pain in his face in 1870. In 1873 there was twitching of the eyelids, and in 1874 the whole of the right side of the face twitched. He suffered from crackling noises in the right ear.

The facial nerve was stretched in Nov. 1878. The twitching disappeared for the rest of that day, and there was no facial paralysis. The following day the twitching recurred. Two years later he was a little better.

* *Berlin. Klin. Woch.*, 1878, No. 40, p. 595.

† *Zeit. für Klin. Med.*, 1881, p. 96.

Schüssler.—Stretching of the Facial Nerve for Convulsive Tic.*

A woman, aged thirty-nine, previously in good health, was affected, without apparent cause, in the summer of 1871, with twitching of the left eyelid, and subsequently of all the left side of the face. This was worse at the menstrual periods. The facial nerve was stretched on Jan. 23, 1879. The twitching ceased, and for twelve weeks there was facial paralysis, which gradually passed off. Six months later there was slight return of the twitching, but it never was as bad as before operation.

Eulenberg.†—Stretching of the Facial Nerve for Convulsive Tic.

A woman, aged twenty-seven, suffered from tic of the whole of the left side of the face. It commenced suddenly in 1877, and spread to the muscles of the neck and to some of those of the hand.

On Dec. 2, 1879, the facial nerve was stretched. The operation was followed by complete paralysis which lasted three months, and then gradually disappeared. The spasms at first ceased, but returned as the paralysis passed off, though not so severely as before operation.

Putnam.‡—Stretching of the Facial Nerve for Convulsive Tic.

A man, aged twenty-five, who had suffered for three years from unilateral spasm of the face, underwent the operation of stretching of the facial nerve on April 24, 1880. For one month after operation there was complete facial paralysis, which did not pass completely away for nine months. At that date there was no improvement.

Bernhardt.§—Stretching of the Facial Nerve for Convulsive Tic.

The patient was a young man, aged twenty-one, who, after exposure to cold in the spring of 1876, was seized with unilateral facial spasm, which continued until 1880.

In June, the upper branches of the facial nerve were stretched.

* *Berlin. Klin. Woch.*, 1879, No. 46, p. 684.

† *Central. für Nervenheilk.*, No. 7, 1880.

‡ *Archives of Medicine*, New York, 1881.

§ *Zeit. für Klin. Med.*, 1881, p. 99.

The operation was followed by relief from spasm and by facial paralysis, which lasted three months. The spasms returned, and at the end of three months were as bad as ever. Three years after operation the patient continued to suffer as much as before.

Godlee and Sturge.†—Stretching of the Facial Nerve for Spasmodic Tic.*

The patient was a lady, aged seventy-two, who six years previously, after the death of her husband, had suffered from twitching of the muscles round the right eye, and subsequently of all the muscles supplied by the facial nerve. As all other treatment failed, on July 20th the facial nerve was stretched. The face remained paralysed for two months. On Oct. 19th, the face at rest was nearly symmetrical, the patient was rapidly improving. In October of the following year, there was slight recurrence of twitching of the eyelid, accompanied by some neuralgia. A blister was applied and quinine was administered. Since then the twitching had twice recurred, each time in connection with mental worry or shock, but it had disappeared again.

Southam.‡—Stretching of the Facial Nerve for Tic.

The patient, a woman, aged fifty-nine, had enjoyed good health until she received a sudden fright two years before coming under notice. She then was seized with unilateral facial spasm, which continued and resisted all treatment.

On Nov. 28, 1881, the facial nerve was stretched. There was resulting facial paralysis which lasted five weeks, and had not completely disappeared in sixteen weeks. Five years later there was no return of spasm.

Hoffmann.§—Stretching of the Facial Nerve for Convulsive Tic.

The patient was a woman who suffered from unilateral facial spasm. The facial nerve was stretched on March 28, 1881. Paralysis ensued and did not completely pass away till the autumn. In May 1881, there was slight return of spasm, but in 1883 the spasms had never become as severe as before the operation.

* *British Medical Journal*, 1881, vol. i. p. 922.

† *Ibid.*, 1800, vol. ii. p. 810.

‡ *Lancet*, Aug. 27, 1881.

§ Godlee's Tables.

Godlee.—Stretching of the Facial Nerve for Convulsive Tic.*

The patient was a man, aged thirty-six, who had suffered for some years without apparent cause from bilateral tic, which was made worse by exposure to cold, bright light, and excitement. He had slight supra-orbital neuralgia on the left side. The left supra-orbital nerve was first divided subcutaneously without good effect, and subsequently the left and the right facial nerves were stretched. In both instances the twitching recommenced after three months as the paralysis disappeared, and finally returned as severely as before the operation.

Putnam.—Stretching of the Facial Nerve for Convulsive Tic.

The patient was a woman, aged forty-five, who for nine years had suffered from unilateral spasm of the muscles supplied by the facial nerve.

On June 1, 1881, the facial nerve was stretched. After the operation there was paralysis of the muscles of the face for at least two months. For some months the spasms departed, but they subsequently returned as severely as before operation.

Southam.—Stretching of the Facial Nerve for Convulsive Tic.

A woman, aged thirty-two, suffered from clonic spasm of the right side of the face of four years' duration. For the relief of this the facial nerve was stretched. The operation was followed by paralysis, which lasted for three months. The effect on the spasm was doubtful, as the patient was lost sight of.

Benedikt.†—In this case the patient was aged and had suffered from an old paralysis, followed by facial spasm. The operation was followed by some improvement, which continued three weeks after operation.

Bernhardt.—Stretching of the Facial Nerve for Convulsive Tic.

The patient was a woman, aged thirty-five, who after long continued use of one eye with a lens whilst drawing, was affected with spasm of the corresponding side of the face. The operation was

* *British Medical Journal*, 1883, June 9, p. 1122; and *Trans. of Clin. Soc.*, vol. xvi, p. 221.

† Keen's Tables.

followed by paralysis, which lasted seven months. The spasms ceased for the same length of time, and then returned, although in a modified form.

*Gray** (two cases).—In the first case the patient was a man, aged thirty-six, who had had facial spasm for sixteen years, and for some time in addition facial neuralgia. The operation of stretching the facial nerve relieved the spasm after three months, but the pain was, if anything, rather worse.

The other patient was a man, aged twenty-one, who was choreic and had suffered from facial spasm for ten years. The operation was followed by paralysis, and three months after operation the spasm remained cured.

Zesas.†—*Stretching of the Facial Nerve for Convulsive Tic.*—*Success.*

The patient was a man, aged thirty-seven, who had suffered for eight years from convulsive tic on the right side. The spasms occurred at intervals of five minutes. No apparent cause. On Nov. 16, 1883, the facial nerve was stretched. From the fifth day after operation the spasms became less frequent, and on Jan. 4, 1884, the patient left the hospital well.

Another case quoted by Zesas and mentioned by Keen, has but few particulars supplied. The patient, a woman, had suffered from tic for seven years, and the spasm entirely disappeared within three days of the operation, though the subsequent result was not known.

Bernhardt.‡—A man, aged twenty-five, after exposure to cold, suffered from spasm of the muscles of the right side of the face, together with partial paralysis, for four and a half years. The operation of nerve-stretching was performed on Jan. 16, 1884, with the result that four months later there was some improvement in the paralysis, but none in the spasm.

Kaufmann.§—A man, aged sixty-one, had suffered for seven years from right facial tic, apparently induced by a violent fit of passion. The facial nerve was stretched on Sept. 16, 1884, and, as no improvement resulted, neurotomy of the same nerve was per-

* *Proceedings of Medical Society, King's Co.*, vol. vii. 1882, p. 127; and Keen's Tables.

† *Rev. des Sci. Méd.*, October 1885.

‡ *Cent. für Chir.*, 1885, No. 3; and Keen's Tables.

formed five days later, but neither operation was productive of any good result.

*Keen.**—In this case the patient was a woman, aged forty-eight, who had suffered for five and a half years from spasm of the right side of the face. The facial nerve was stretched on April 2, 1886, with the result that two months and a half later the spasms had entirely ceased, and facial paralysis continued. The infra-orbital nerve had previously been stretched without permanent relief.

It must be confessed that the operation has not been altogether a successful one, but, on the other hand, it is one which, although troublesome to perform, is free from danger, so that, even if it fails to produce the desired result, at any rate no serious or disfiguring wound has been inflicted, and for this reason nerve-stretching is certainly worthy of trial if other treatment has failed.

Keen sums up the results as follows:—

In three cases there was absolute relief for a week, followed by improvement for two years in one case, but no permanent improvement in the other two.

In five cases there was absolute relief for from three weeks to four months, followed by relapse.

In six cases there was absolute relief for from four months to a year, followed by relapse to the previous condition in three, and partial relapse in the other three.

In one case there was absolute relief for five years.

In one case there was absolute relief for two years.

In two cases there was absolute relief for three months.

In one case there was absolute relief for two years and eight months; and all without recorded relapse.

In two other cases the patients were reported cured three days, and two months and a half, respectively after operation.

Operations on Nerves for the Cure of Wryneck.—

I do not think that operations on the spinal accessory nerve should in any way supersede the ordinary surgical treatment of wryneck. They should rather supplement it, and should be reserved for cases that resist the usual remedial measures.

The cases in which operations on the spinal accessory nerve are most likely to be of benefit are those in which there is clonic spasm, and the operation I would prefer to perform would be that

* *Annals of Surgery*, July 1886.

of nerve-stretching, leaving neurotomy or neurectomy for future use if this should fail.

Mr. Ballance has published an excellent paper on the subject in vol. xiv. of *St. Thomas's Hospital Reports*, where, having detailed a case of his own, he says:—

“The first recorded case in which the spinal accessory was divided is narrated in the *British and Foreign Medico-Chirurgical Review* for July 1886. The operator was the late Mr. Campbell de Morgan, and he made his incision along the posterior border of the sterno-mastoid, and thus having found the trapezial branch of the nerve he dissected forwards through the muscular fibres until the main trunk was reached. Professor Annandale* made his incision along the anterior border of the muscle, commencing at the mastoid process and extending it downwards for three inches. . . . Very few cases have been recorded in which spasmodic wryneck has been treated by operation. Mr. C. de Morgan's first case, already alluded to, was quite successful. His second † was complicated by spasmodic movements of the right arm and hand, and yet the relief gained by the operation was very considerable. It has one point of resemblance to my case—viz., the great pain complained of in the region of the masto-occipital attachments of the affected muscles. Professor Annandale's case was also successful. Mr. Jacobson, of Guy's Hospital, writes to me that he excised a portion of the left spinal accessory in a middle-aged woman some six or seven years ago. The operation gave only temporary relief, as other muscles became affected. Mr. Jacobson adopted the incision at the posterior border of the muscle, following the nerve forwards and upwards through the muscular fibres.

“At the meeting of the Manchester Medical Society, last April (1885), Mr. Hardie related one case and Mr. Southam two cases of spasmodic torticollis, which had been successfully treated by section of the spinal accessory. Mr. Rivington and Professor Stromeyer each mention a case in which the operation was performed, but do not give any details. Professor Thiersch and Dr. Kölliker, of Leipzig, have informed me that though spasmodic torticollis is not quite unknown in Germany, yet they were not aware of any case in which section of the nerve supplying the affected muscles was attempted. Professor Thiersch, however, told me that many years ago he operated with success upon an Oriental, dividing the spinal accessory and several cervical nerves on both

* *Lancet*, April 1879.

† *Ibid.*, Aug. 3, 1867.

sides of the neck for the relief of spasmodic contractions, which produced nodding movements of the head."

Mr. Ballance's own case was that of a woman, aged sixty-eight, who had for ten years been affected with spasmodic contractions of the right sterno-mastoid and trapezius. For the relief of this, one end of the spinal accessory nerve was excised before it entered the sterno-mastoid muscle, and the patient was thereby greatly relieved, so that four months later she was almost free from spasm and was still improving.

To the cases collected by Mr. Ballance the following may be added:—Sands reports two cases of spasmodic wryneck cured by resection of a portion of the spinal accessory, and Tillaux one case in which much improvement followed a similar operation. Hansen in two cases obtained a cure by stretching combined with resection, whilst Lange failed to cure a similar case by nerve-stretching, and Kuster * merely gave partial relief to another patient by the same operation. F. Page, however, reports a case in which wryneck followed an injury to the cervical spine, and was cured by stretching the spinal accessory nerve.†

I append brief notes of some of these cases.

Sands.‡—Excision of a portion of the Spinal Accessory Nerve for Spasmodic Wryneck.

The patient was a man, aged thirty-nine, who came under observation in May 1882. The wryneck was of nine months' duration. Various local and internal remedies had been tried in vain. Three inches of the spinal accessory nerve were removed. The wound healed in nine days. Soon after the operation the contraction of the muscle gave way, but the sterno-mastoid remained paralysed and atrophied. For some time afterwards there was a certain inclination of the head to one side, but it gradually yielded.

Sands.—Excision of a portion of the Spinal Accessory for Spasmodic Wryneck.

In a patient, aged thirty-one, suffering from wryneck, half an inch of the spinal accessory nerve was resected. The wound

* Quoted by Fenger and Lee; *op. cit.*

† *British Medical Journal*, 1888, vol. i. p. 245.

‡ *Rev. des Sci. Méd.*, 1884, vol. xxiv. p. 296.

healed well. For some weeks the patient had difficulty in keeping his head straight, but he finally was completely cured.

Tillaux.—Resection of the Spinal Accessory Nerve for Wryneck.*

The patient was a woman, aged thirty-two, who suffered from a peculiar form of spasmodic wryneck. After treatment by galvanism without benefit, it was decided to operate upon the spinal accessory nerve. Before operating M. Tillaux experimented upon a dead body, and found that when he stretched the spinal accessory nerve there was distinct dragging upon the medulla. For this reason he did not stretch the nerve, but removed a portion of it from the posterior border of the sterno-mastoid. The operation was followed by much relief to the previous symptoms, but not by a complete cure.

Hansen.†—Stretching and Excision of a portion of the Spinal Accessory Nerve for Wryneck.

A woman, aged thirty-two, had suffered for six months from spasmodic torticollis. The spinal accessory nerve was exposed at the posterior border of the sterno-mastoid muscle, was first vigorously stretched, and then twelve millimetres were excised. The spasms ceased.

Hansen.‡—Stretching and Excision of a portion of the Spinal Accessory Nerve for Wryneck.

A woman, aged thirty, had suffered for a year and a half from spasmodic wryneck. The spinal accessory nerve was stretched, and thirteen millimetres were excised. Slight spasms continued for one month. After this time recovery was complete.

Lange.§—Stretching of the Spinal Accessory Nerve for Wryneck.

In a case of spasmodic wryneck, Lange stretched the spinal accessory nerve. At first there was improvement, but some weeks later the patient was as bad as previously.

It will thus be seen that both nerve-stretching and neurectomy

* *Gazette des Hôpitaux*, 1882, p. 109.

† Quoted by Fenger and Lee, *op. cit.*

‡ *Loc. cit.*

§ *Rev. des Sci. Méd.*, 1884, vol. xxiv. p. 298.

may claim to have given relief, but that each of them also has failed in other cases. It cannot therefore be said that either operation is to be looked upon in the light of a certain cure; the prognosis should always be guarded, and other treatment should not be neglected. The operation of neurectomy appears in these cases to be more certainly beneficial than that of nerve-stretching.

Nerve-stretching for Traumatic Paralysis.—Various cases of the cure of traumatic paralysis by nerve-stretching have been recorded, but, from the descriptions given, I can have no doubt that in all the nerve-trunk had either been wounded itself, or else was compressed by scar tissue or displaced fragments of bone.

In all such cases the nerve should be exposed at the seat of injury, and treated in the manner I have already described when dealing with the question of injuries of nerves.

Anæsthetic Leprosy treated by Nerve-Stretching.—In 1881 Laurie reported in the *Lancet*, and Wallace in the *Indian Medical Gazette*, some results of the treatment of anæsthetic leprosy by nerve-stretching. These results were satisfactory as far as the relief of anæsthesia and of pain were concerned, and since this date the operation has been extensively practised in India. The disease is not one which is met with, except on rare occasions, in England, and, as I have had no opportunities of seeing the treatment in question carried out, I am necessarily dependent upon the accounts of others.

One of the latest papers—and though a short one, yet of much value—is by Neve, in the *Edinburgh Medical Journal* for 1884, vol. ii. p. 433. This author gives the statistics of all the cases operated upon at the Kashmir Mission Hospital, 190 in number. The operations were performed by Dr. Downes and Dr. Neve on 90 patients. Of these, 84 improved and recovered sensation, two did not improve, and four died.

The form of leprosy met with in the district was not of the tubercular nature, but, as a rule, simply affected cutaneous sensation, causing first hyperæsthesia, and then anæsthesia.

“From the third to the sixth day after operation improvement is usually noticed. The restoration of sensation is centrifugal and gradual. . . . It may be three weeks before the restoration of sensation is complete, and sometimes it never entirely becomes so.

“Coincident with increasing sensation, the whole nutrition of the limb advances. There is a tendency to healing of ulcers and

disappearance of tubercles. In two cases in which one limb was operated upon, the opposite limb improved, but to a lesser degree.

"Improvement has been most rapid and most marked where most strain has been applied during the operation, and the few cases of non-improvement which have come under my personal observation have been all attributable to insufficient stretching.

"By the third week the improvement can be gauged, but more may follow. On the other hand, it may retrograde. This has not occurred in any case remaining in our leper asylum for treatment. I have, however, seen two patients who returned, stating that about four months after operation anæsthesia recurred. On one of these I re-operated with success. Recurrence I take to be rare. I have had many cases under my care for more than a year, and others have been seen as long after operation, in all of which improvement of sensation had been permanent, and of nutrition progressing."

In another paper by Downes, read before the Medical Society on May 20, 1886, it is stated that in thirty-two cases in which operations were performed, in all the patients derived some benefit, and in some the ulcers healed.

Dr. Beavan Rake has still more recently published the results obtained by him in Trinidad, operations having been performed one hundred times on sixty patients.*

Dr. Rake concludes that pain is almost always relieved; that anæsthesia is rarely improved; that the operation does not influence the growth of tubercles; and that ulcers occasionally heal.

It will thus be seen that not only is sensation restored, but the other nervous functions are improved. Considering the thickening of the nerve by fibrous tissue found in the cases of anæsthetic leprosy, it is probable that the operation acts by freeing the nerve-trunk from adhesions.

* *British Medical Journal*, Dec. 22, 1888, p. 1373.

CHAPTER XXIII.

NEURALGIA AND ITS SURGICAL TREATMENT.

It is quite beyond the limits of the present work to consider neuralgia from a medical standpoint, and I do not propose to enter into the subject more deeply than is necessary for an adequate conception of the relation in which surgery should stand to this most painful, and often most obstinate, affliction.

The *causes* of neuralgia are predisposing and exciting.

With regard to the first, an hereditary tendency to nervous affection—*e.g.*, epilepsy or lunacy—is most important.

Any debilitating influences, whether mental or physical, predispose to neuralgia.

The *chief exciting causes* are—First, exposure to cold; second, injury of nerves; third, pressure upon or irritation of nerve-trunks; fourth, peripheral irritation; fifth, irritation or disease of the central nervous system.

First. Exposure to cold appears to act by setting up inflammatory changes around the nerve, but the exact manner in which the nerve is affected is not certainly understood.

Second. Injury of a nerve from whatever cause may result in neuralgia. I have already alluded, and shall again allude, to the neuritis that may be set up; but, independently of that, pain of a neuralgic nature may follow upon any uncomplicated nerve injury.

Third. Nerve-trunks may be compressed or irritated in various ways. Thus a tumour of a nerve, or else a tumour pressing upon a nerve, may cause severe neuralgic pain—*e.g.*, the neuralgia caused by pressure of a thoracic aneurysm on the intercostal nerves is sometimes very severe.

The implication of nerves in the scars of cicatrizing wounds affords an excellent example of pressure by inflammatory exudation. Sometimes slight wounds of the digits or other parts are followed by extremely tender cicatrices, pressure on which at one particular spot causes intense shooting pain due to the inclusion

of a small nerve filament at this point. The implication of nerves in fractures, pressure on them by foreign bodies, such as bullets, &c., afford further examples of neuralgia caused by irritation or pressure. (Other instances may be found on alluding to the chapters on "Varieties of Nerve Injuries.")

Fourth. Peripheral irritation may reflexly cause neuralgic pains in very distant parts. The following may be adduced as instances of this reflex neuralgia:—A stone in the kidney may cause neuralgia of the testis. A carious tooth may cause neuralgia in any of the branches of the fifth nerve. A wound in the hand may cause pain in the arm and neck. Such instances might be indefinitely multiplied.

Fifth. The irritation of a tumour pressing upon the brain or spinal cord may cause neuralgic pains in distant parts. Thus, I have seen a case of sciatica treated by nerve-stretching and other remedies which was really dependent upon a sarcomatous growth compressing the cord. Similarly, pressure on the spinal cord or nerve-roots in spinal caries, with angular curvature, often results in severe pains in the chest and abdomen.

Structural disease of either the brain or spinal cord may produce similar symptoms.

I have enumerated above the various exciting causes of neuralgia, yet, in the vast majority of cases, none of them are present. The great majority of neuralgias, which occur more in women than in men, and in those who are anæmic or dyspeptic, which, apparently, often depend upon mental worry or overwork, and often come and go without evident cause—these have no morbid anatomy. No lesions can be discovered post mortem, either by the naked eye or the microscope; the pains may pass and leave no trace of their presence; they may be amenable to one drug in one patient and not in another, and at one time and not at another. The treatment of such cases does not often require surgical interference, and in all cases attention to hygienic conditions—such as plenty of exercise, good and easily digestible food, and avoidance of overwork and of mental worry—should have the foremost place in treatment.

Symptoms of Neuralgia.—The one essential symptom is pain. This pain is localized more or less accurately to the area supplied by a certain nerve or nerves. It is usually described as of a darting, shooting, or plunging character, and generally radiates from a central point. Pressure upon the spot where the affected

nerve emerges from beneath the deep fascia or from a bony canal intensifies the pain.

Epileptiform Neuralgia.—Epileptiform neuralgia is the name given to a very severe, and fortunately rare, form of this disease, which, from its obstinacy, is very liable to come under the notice of the surgeon. This most painful affection (which was originally described by Trousseau in his *Clinical Medicine*) almost invariably attacks the face, and may follow the course of any one or of all of the branches of the fifth nerve.

There are two varieties. In the one the pain is accompanied by spasm and twitching of the facial muscles; in the other there is no such spasm. The pain is not constant, but paroxysmal, and is liable to much variation. As in other forms of neuralgia, many weeks or months may elapse between the attacks, which, when they supervene, are liable to be repeated day after day for a considerable time. The patients vary in age, sex, and constitution. They may be old or young, men or women, robust or weakly. The paroxysms of pain are of a most startling character, and their onset is very sudden. Their duration varies from four or five seconds to half a minute, seldom exceeding the latter limit. Such paroxysms may be repeated with hardly any perceptible interval, and may be started by various causes, most of which act on the peripheral distribution of the fifth nerve.

Quite suddenly, without a moment's warning, a breath of cold air, an attempt to swallow liquid or to masticate food, the slightest touch of the hair of the face or of the skin, an attempt at speaking, or a sudden noise, may be followed by severe pain, which, commencing at a single spot, rapidly radiates over the whole of the branch of the nerve which supplies the surrounding area, and spreads in many cases to the remainder of the face.

At the onset of the paroxysm the patient frequently appears to lose self-control. He grasps his head with both hands as though he would crush it; he clenches his teeth, clutches violently at surrounding objects, or writhes in agony on the floor. It is impossible to exaggerate the sufferings of these patients.

The precise character of the pain varies at different times and in different people. To some it is "like a bundle of red-hot wires being driven into the face and then twisted in all directions." To others it is of a stabbing and cutting character. Some patients describe the pain as similar to that experienced by severe crushing of a part; others say it is "as if the flesh was being torn away."

The mucous membrane of the lips, gums, and nasal cavities is just as much the seat of pain as is the skin; and in some instances the secretions are variously altered, the nostril becoming hot and dry, or the eye becoming full of tears.

On account of the frequency with which movements of the mouth cause an attack, the patient often presents an appearance of extreme caution in his actions. When speaking, he does so with clenched teeth and with lips scarcely parted. In eating and drinking his movements are very slow. His face is kept wrapped up to prevent the contact of any foreign body or of a rush of cold air.

Sometimes, under the perpetual mental strain, the patient's health gives way, for he is often almost incapacitated from sleeping, eating, and drinking, and his whole thoughts are concentrated upon himself. In other instances the health is surprisingly maintained, and the general appearance of the patient, when free from pain, is often most deceptive. Occasionally the subjects of epileptiform neuralgia seek relief from their sufferings in suicide, a termination which sufficiently emphasizes the severity of the complaint.

Treatment of Neuralgia.—Apart from medicinal treatment, which will not be here considered, and apart from attention to the general health, the first essential is to discover and remove the cause of the neuralgia. Thus, search should be made for any tumour or inflammatory growth on the nerve-trunk, for any source of peripheral irritation, and for disease of the central nervous system.

In many cases, counter-irritation by means of blistering fluids, iodine, &c., produces excellent results: and in cases of neuralgia of the extremities, a thorough course of "massage" and shampooing is often most beneficial. Galvanism, especially in neuralgias of the extremities, sometimes gives the greatest relief. It should be applied for a space of ten or fifteen minutes daily, and must be persevered in for several weeks before a cure can be expected. The current need not be a very powerful one.

For cases in which pressure on a nerve has caused neuralgic pains I would refer to what I have already written in the chapters on "Varieties of Nerve Injuries;" for similar instances due to neuroma, to the chapter on "Tumours of Nerves."

Operative Treatment of Traumatic Neuralgia.—After injury to any part of the body, but more particularly to the

extremities, severe neuralgic pain may persist and continue for an indefinite time after the immediate symptoms caused by the injury have passed away. This pain may be due to various causes.

In cases of wound it may be due to direct injury of the nerve-trunk with consequent thickening and formation of a traumatic neuroma. In other cases the nerve-trunk may be compressed by cicatricial tissue formed in the process of healing. In yet others no nerve-trunk may be implicated at all, but all the symptoms may arise from implication of a small nerve filament in the cicatrix, as in the instances I have already described when dealing with the "Varieties of Nerve Injuries." Occasionally, but rarely in my opinion, the pain may be due to a neuritis set up by the injury.

The symptoms are simply those of neuralgic pains radiating along the course of a nerve or nerves, and intensified by pressure on the nerve-trunk. In addition to the pain there may be symptoms indicating implication of the motor or trophic fibres, and consequent paralysis or trophic lesions. Such additional symptoms are by no means necessarily or even frequently present in cases of traumatic neuralgia.

The treatment of patients suffering in this way may at first be conducted on general principles, but in many instances it is necessary to have recourse to operative measures.

Where, as in the fingers, there is reason to believe that a nerve filament may have been implicated in the scar, an excision of the cicatrix will usually result in a complete cure.

In other cases, where there is reason to believe that a nerve-trunk has been either wounded or else compressed by cicatricial tissue, the proper treatment is to cut down at the seat of injury, expose the nerve-trunk, free it from the surrounding tissues, and then thoroughly stretch it. The benefits to be derived from the latter operation alone are doubtless considerable, but I am confident that if it be considered advisable to expose the nerve-trunk at all for the purpose of stretching it, the proper place to choose for the operation is the site of the injury.

The following cases afford examples of the various kinds of injuries which may cause traumatic neuralgia, and of their treatment by nerve-stretching. For instances of implication of nerve-twigs in scars I would refer to an earlier chapter.

CASE I.—*Smith.*—*Neuralgia of Finger following a blow.—Stretching of the Digital Nerve.—Cure.*

Philip L., aged twenty-three, was admitted into St. Bartholomew's Hospital on July 7, 1885. The patient was a healthy-looking man, and said he had never ailed anything. Three years ago he had been struck by a cricket-ball at the end of the middle finger of the left hand. The blow caused him much pain at the time, and ever after the injury he suffered from pain in the injured part. This was worse in the year previous to his coming under notice, and quite prevented him from following his occupation as a tailor. Present condition: The pain is of a neuralgic nature, and is felt along the line of the median nerve as far as the clavicle. It is worse at night, and prevents him from sleeping. His family history is good. An examination of the hand only shows that the left middle finger is rather thin and tapering. Extreme flexion is not possible on account of pain. There is some doubtful tenderness along the course of the median nerve.

July 8th.—The digital branch of the median nerve on the radial side of the middle finger was exposed opposite the middle phalanx, and stretched.

9th.—Has had much pain since the operation.

13th.—Discharged. Still has pain, though it has diminished.

Sept. 1st.—Patient reports himself as quite cured and able to do his work. Has had no pain since the week after he left the hospital.

CASE II.—*Ashurst.**—*Stretching of the Musculo-cutaneous, Median, Ulnar, Internal Cutaneous, Lesser Internal Cutaneous, and Musculo-spiral Nerves for Traumatic Neuralgia of the Forearm and Hands.—Improvement.*

A man, aged thirty-three, was admitted into hospital, Dec. 1881. In June of that year, while walking on deck, he was struck by a heavy sea, which carried him about twenty feet and dashed him against the deck. He was rendered insensible for ten minutes, and when he regained consciousness he had some pain in the neck and shoulder, which continued steadily for two months. Since then this pain has been better, and now only appears after exertion. Shortly after the accident the left hand became swollen,

* *Philadelphia Medical Times*, Feb. 11, 1882.

and remained so for four months. Two months after the accident the left arm was swollen for three days. He noticed after the accident that the left hand could not be opened widely. The sight was impaired, but has improved. At the same time he had extreme hyperæsthesia over the left side of the face and trunk. Five months after the injury pains appeared in the forearm and hand; they were of a paroxysmal character, and became very intense. On admission he was found to have slight ptosis and impairment of sight on the left side; pain in the neck and shoulder after exercise; paroxysmal dull pain in the left forearm and hand; the muscles of the shoulder, forearm, and hand wasted and powerless; slight sensation in the arm, but none in the forearm or hand. Pain aggravated by pressing on a lump at the end of the sternum. On Dec. 3rd the whole of the nerves of the upper extremity were stretched in the axilla. The operation wound healed rapidly, and the patient was treated by the galvanic current for two hours a day. Two weeks later the muscles of the upper arm could be distinctly acted upon by moderately strong interrupted currents, and the will was capable of producing some little movement of the muscles. The arm also was much easier.

CASES III. and IV.—Two other cases of traumatic neuralgia, under the care of Dr. Ashurst and treated by nerve-stretching, are recorded by Chandler. In one, the musculo-spiral was stretched with temporary relief. In the other, the median nerve was stretched and a complete and permanent cure resulted.

CASES V. and VI.—Ridal* describes two cases of injury to the back without fracture, followed by neuralgic pains. In one case the pain was referred to the course of the anterior crural nerves, and was cured by stretching these trunks. In the second patient there were symptoms of hæmorrhage into the spinal canal, but at the end of four months the patient was unable to walk, and had severe pains in both lower extremities. Both the sciatic nerves and both the crurals were therefore stretched. In a fortnight the patient could walk, and gradually all pain departed from the limbs.

The following cases supply further evidence of the value of

* *Deut. Med. Woch.*, vol. i. 1882.

nerve-stretching in this form of neuralgia, and show from what different accidents and local conditions pain may result. They also show that although the operation is generally useful, it is by no means always successful, and it is evident from a consideration of the cases recorded that too good a prognosis must not be given.

CASE VII.—*Wales.*—Nerve-stretching for Traumatic Neuralgia.—Cure (?)*.

A lieutenant in the Navy, aged thirty-five, was thrown down by the sudden lurching of the ship, and fell on the deck, striking his left elbow with great force. Severe pain followed, which lasted but a few minutes and then passed away. On the following morning sensation was impaired in the little finger and adjoining side of the ring finger, and there was a return of pain in the forearm. This condition continued for four weeks, when the pain became much aggravated by use of the arm, especially in writing. The pain increased in intensity, and extended from the shoulder the whole length of the arm, along the course of the ulnar nerve. He was treated by various methods, but, as the pain became excruciating, the ulnar nerve was exposed behind the internal condyle and was forcibly stretched. Immediate relief from the pain followed, but in a few days it returned and was as severe as before. Shortly afterwards he was seized with malarial fever. Two days after the fever set in the pain left the arm and did not return.

CASE VIII.—*Czerney.†—*In a case in which there had been suppuration around the elbow-joint, the inflammation was followed by neuralgia in the distribution of the ulnar nerve. The latter was therefore exposed in the axilla and stretched. The patient's condition was improved, but the recovery was not perfect. The proper treatment would have been to expose the nerve at the seat of suppuration, as in the following case.

CASE IX.—*Vogt.‡—*A woman suffered from severe neuralgic pains in the distribution of the ulnar nerve after a wound on the inner side of the forearm. An exploratory operation showed that the ulnar nerve was surrounded and compressed by cicatricial tissue. From this it was freed, with complete relief to pain.

* *New York Medical Record*, vol. xxii. p. 26.

† Quoted by Fenger and Lee.

‡ Quoted by Blum, *op. cit.*

CASE X.—Estlander.*—After a bullet wound through the arm a patient suffered from neuralgia in the distribution of the median nerve. The nerve was stretched, and the pain ceased for twenty-four hours. This was followed by a relapse for three weeks. After this time the pain gradually decreased, but the recovery was not perfect.

CASE XI.—Maag† records a case in which, after a punctured wound of the hand, the patient suffered from neuralgic pains with contraction of the thumb and forefinger. The median nerve was stretched, and the patient recovered.

CASE XII.—Morton and Cox.‡—A man received a wound on the ulnar side of the forearm. After it had healed, the patient suffered from neuralgic pains and numbness in the distribution of the ulnar nerve. The latter was therefore stretched. The pain was cured by the operation, and did not return.

CASE XIII.—Omboni§ describes a case in which neuralgia with obstinate contractions of the forearm, and neuralgic pains of the left side of the thorax, followed an extensive abscess in the axilla. Other treatment having failed, the brachial plexus was stretched. The pain ceased, the contractions of the forearm passed away, and seventy-four days later none of the previous symptoms had recurred.

CASE XIV.—Petersen.||—A man, after an incised wound of the leg, suffered from severe neuralgic pains in the injured limb. An examination of the parts showed extreme tenderness along the course of the posterior tibial nerve. This was therefore cut down upon and stretched, with the most satisfactory results. The pains entirely ceased, and did not return.

CASE XV.—Poulet.¶—*Bullet Wound of the Median and Ulnar Nerves with Spasm—Brachial Plexus Stretched.—Cure of Spasm and Pain.*

An Algerian soldier was struck by a bullet on the inner and front part of the arm just above the elbow. The bullet divided

* Quoted by Fenger and Lee. † *Ibid.*, *op. cit.*

‡ *American Journal of Medical Science*, Jan. 1878.

§ *Annali Univ. di Med. Chir.*, Jan. 1880.

|| *Rev. des Sci. Méd.*, 1877, vol. ii. p. 285.

¶ *Bull. et Mém. de la Soc. de Chir.*, 1884, p. 939.

the median and ulnar nerves and the brachial artery. From the very moment of the accident the hand became quite paralysed, and spasmodic movements commenced in the forearm. Ten months later the spasms continued and were accompanied by much pain. Poulet then stretched the nerves of the upper extremity in the axilla. The operation gave relief to the pain and spasms, but the paralysis remained.

CASE XVI.—Purdie.*—In a case of suppuration around the end of a finger and under the nail, the inflammation was followed by neuralgic pains in the finger. The digital nerves were stretched, when the pain ceased and did not return.

CASE XVII.—Spence† records the case of a patient who suffered from severe pain of a neuralgic nature after a whitlow. Stretching of the digital nerve of the finger affected entirely cured the pain.

CASE XVIII.—Kuster.‡—In a case of sciatica, consequent upon a bullet wound, the sciatic nerve was twice stretched. On the first occasion no benefit resulted. The second operation was followed by recovery.

Neuralgia of Stumps.—The form of neuralgia which is liable to follow on amputations is unfortunately but too well known to surgeons in its clinical aspect. Its pathological aspect has, however, been comparatively little studied.

The symptoms of this affection need but little description, yet there are some points worthy of notice. The neuralgia frequently does not make its appearance until some time after the healing of the amputation wound, and it is comparatively rare for any severe pain to be felt before the lapse of some months.

The earliest symptoms are generally referred to the extremity of the limb that has been removed, and shooting, pricking, or numbing pains are complained of as being felt in the fingers or toes.

Frequently the pain is referred to the periphery, but as the case progresses it is liable to extend to that part of the limb that remains.

The position of the removed limb and of its several parts is felt abnormally plainly: thus, some patients I have seen have been able to name exactly the position of each finger.

* *Lancet*, 1878, vol. i. p. 904.

† *Ibid.*, 1880.

‡ Quoted by Fenger and Lee.

Occasionally, as remarked by Mitchell, that part of the removed limb which lay between the seat of amputation and the extremity is not felt, and the hand or foot appears to the patient as if attached to the end of the stump. I think this is not a very frequent illusion.

In addition to the shooting and other pain of a neuralgic nature, the patient frequently suffers from a sensation of painful contraction of the amputated parts: thus, I have heard people say that the fingers seemed clenched into the palm of the hand, and that they were unable to open them out.

In many cases of long standing the muscles of the stump become the seat of spasmodic twitchings and fibrillar contractions, and these may subsequently extend higher up the limb.

The stump is generally extremely tender, and the skin over it is hyperæsthetic. Pressure on the stump exaggerates the pain.

The nerve-trunks of the stump are frequently tender, and very sensitive to pressure; the pain may be referred to them, as in cases of idiopathic neuralgia. The bulbous extremities of the nerves may often be felt in the scar. They are usually in a very sensitive condition.

The skin of a neuralgic stump is often quite natural in appearance, but in some instances it presents various of the conditions described in cases of nerve injury as of a trophic nature: thus, it may be shiny, glazed, and glossy, or may have numerous small ulcers upon it.

The pathological conditions that excite neuralgia of stumps are strictly comparable with those met with in other varieties of Traumatic Neuralgia (which see). Thus, the symptoms may be dependent upon pressure on the nerve-endings by scar-tissue; adhesion of the bulbous ends to the scar in such a position as to expose them to pressure by any artificial limb; and, in addition, as in other cases of traumatic neuralgia, the symptoms may be dependent upon a chronic, and perhaps ascending, neuritis, such as I have described under the head of Traumatic Neuritis.

All these troubles are best obviated in the first instance by taking care to cut all the nerve-trunks short at the time of operation.

It will be seen that the symptoms of neuralgia of stumps are in many cases identical with those of neuritis, and the pain, muscular spasm, and trophic lesions in the stump are all such as occur in the latter affection.

I have already quoted some examples of neuritis occurring in stumps, and will now only venture to narrate briefly some instances in which chronic ascending neuritis has been found to be present.

Mitchell * records the case of a man whose leg was crushed in a railway accident on Aug. 1, 1862. Amputation was performed on Aug. 12th at the junction of the lower and middle third. In 1863, a year after the injury, re-amputation was performed for neuralgic pain. In May 1864 Dr. Nott removed the stump again. In June of the same year one inch of the sciatic nerve and three inches of the popliteal and peroneal nerves were excised. All of them were enlarged. No relief followed, and in May 1865 an amputation of the thigh at the junction of the lower and middle third was performed. The sciatic nerve was seen to be engorged, and double its natural size. Neuralgia continued, and in the August following neurectomy of the sciatic was performed where the nerve leaves the pelvis, an inch and a quarter being removed, the upper part of which alone appeared healthy.

Nepveu† records the case of a man, aged forty-four, who came under his care in 1880. In 1855 he had suffered from frostbite of his foot, and had lost a toe. The foot remained numb, and many years afterwards was amputated on account of obstinate ulceration. The operation wound healed well, but the stump soon became the seat of violent neuralgic pains, with spasm of the muscles and ulceration of the skin. Spasms of the muscles of the other leg also were noticed. For the relief of these symptoms re-amputation in the upper third of the leg was performed, but without material improvement for some months, after which time the pain and spasms gradually passed away. An examination of the amputated stump showed that the posterior tibial nerve was thickened and adherent to the cicatrix, and that it, as well as the anterior tibial and long saphenous nerves, were hard and fibrous. Microscopically examined, all these nerves in their whole extent presented the usual thickening and destruction of nerve-fibres met with in chronic neuritis.

Treatment of Neuralgia of Stumps.—In addition to the treatment applicable to all cases of traumatic neuritis, it is certainly advisable not to delay operative measures. It should be remembered that where there is an ascending neuritis, the inflammation of the nerves may pass beyond the reach of the surgeon if too long a time be allowed to elapse.

* *Op. cit.*, p. 285.

† *Rev. de Chir.*, 1881, p. 19.

In almost all cases I would advise that the main nerve-trunks should be exposed at the seat of the scar, and, after thorough stretching, that their bulbous extremities and two or three inches of the nerve-trunk above should be excised.

No fear need be entertained lest such treatment should cause numbness of the stump. Its nerve-supply is derived from branches given off far above, and will not be interfered with in this way.

I believe that, in most cases, temporary benefit at least will result from such treatment, and that a considerable proportion will be permanently cured if the operation has not been too long postponed.

If the pain recurs, I believe that the best thing to do is to expose the nerve-trunks at a higher level, and to stretch them thoroughly.

This treatment was first carried out by Mr. Callender, who in the *Lancet* for 1875 recorded a case of successful stretching of the median nerve for neuralgia following amputation of the forearm. The patient, however, was not kept under notice for any length of time.

I have myself seen cases treated by nerve-stretching, and generally with relief to the symptoms, at any rate for a time. In one case, which is yet under observation, each operation of nerve-stretching gives relief for four or five months or thereabouts; and I have been much interested in noticing that after each operation the pain does not at once disappear, but rather is at once greatly improved and then passes away in about a week. It seems as if the operation acted not only through the mechanical lesions produced on the nerve-trunk, but that some further and more gradual change took place in either the nerves or their centres.

I do not think that re-amputation holds out any greater prospect of relief to cases of neuralgia of stumps than does resection of the nerve-ends. I believe that it is usually only beneficial on account of the removal of a certain amount of the nerves with their bulbous ends. There are, however, some cases in which the stump is conical, and the bone tends to protrude, and in such, no doubt, re-amputation should be performed.

In severe and obstinate cases, it may be necessary to perform neurectomy close to the origin of the nerve-roots from the spinal cord, but even then there are instances in which, in all probability, the centres are affected and in which all operations will prove useless.

Treatment of Facial Neuralgia by Surgical Means.—

It is quite impossible to draw any definite line between those cases which are bad enough to require surgical interference and those which should be treated by internal remedies. I take it for granted that no one would operate without first trying all medicinal remedies in which he may place faith. The fact is that the patient must to a great extent be the judge of his own malady, and to him must be left the question whether the pain he suffers is sufficiently severe to make it worth his while to undergo an operation, which, in most cases, is a trifling one, but in some is of considerable magnitude.

Yet it would be a mistake to think that the question is one entirely for the patient. It is not so. There are many cases of neuralgia which are much more dependent upon an hysterical condition than upon any local one, and in such operations are not likely to be beneficial, and should not be performed. They will only be brought into disrepute. Likewise, no operation is advisable in patients who persist in living in circumstances which are conducive to bad health. So that in those who refuse to take sufficient exercise and sufficient food, and whose illness is to a great extent due to constant brooding over their own ills, no operation should be performed.

It has seemed to me that there are two great classes of facial neuralgia :

First. Those that may be excited by peripheral irritation of some branch of the fifth nerve.

Second. Those whose origin is independent of all peripheral excitement.

For the present I do not propose to treat of "epileptiform" neuralgia, but on theoretical grounds it is evident that operative measures are more likely to succeed in the first than in the second class.

I do not think that in most cases of facial neuralgia there is really any peripheral nerve disease. I believe that such is indeed very rare. On the other hand, I am disposed to think that the condition is a central one, and is due to an over-excitability of the nerve-centres. If such is the case, it may fairly be asked how any operation on the peripheral nerves can be expected to be beneficial. I think this question is easier to answer than appears at first sight.

The only operations that are practised for the relief of neuralgia

are those of nerve-stretching, neurotomy, and neurectomy. All of these act by interrupting the communications of the nerve-trunks for a time.

I believe that the patients to whom any good is done by operations derive benefit solely by the application to them of the maxim which holds good in all surgery—*that diseased parts should be kept at rest.*

If irritation of the supra-orbital nerve or its branches causes neuralgic pain, in my view of the matter this results from the extreme irritability of the nerve-centre, and not necessarily from any morbid condition of the nerve itself. The operation of nerve-stretching or of neurectomy acts mainly by preventing any stimuli from reaching the hypersensitive centre, and by thus placing it at rest. It is possible that nerve-stretching may, in addition, cause some alterations in the nutrition of the nerve-centre itself in the manner already alluded to when writing of the physiological effects of nerve-stretching, but I would rather attribute any good results to the mechanical effects produced on the nerve-fibres themselves.

What operation, then, should be performed? I believe that the operation most calculated to give relief is that of nerve-stretching. I think that it is beneficial in proportion as it acts on a larger scale and extends its influence over a larger area than does neurotomy or neurectomy, except when by the latter a great length of nerve is removed. If any branch of the fifth nerve be exposed and thoroughly stretched, both in a direction away from and towards its periphery, the various small branches given off at varying distances are also included in the effects produced. In them also there is a tendency to diminish the conductivity and to break the nerve-fibres themselves, and thus a much greater effect is produced than by simply dividing the nerve-trunk.

The operation of neurotomy can only act by mechanically separating the nerve-fibres at one place, and is therefore less likely to produce benefit than is nerve-stretching.

The operation of neurectomy was originated under a complete misapprehension of the manner in which nerves unite after injury. It was supposed that a return of sensation in a part rendered anæsthetic by neurotomy implied reunion of the divided nerve. In dealing with the question of "union of nerves," I have already shown that sensation may be restored when the nerve-ends are quite separated, and there are plenty of instances in which this

has been proved. In the face more than anywhere else this nerve anastomosis is most perfect, and no doubt accounts for numerous failures in the operative treatment of neuralgia. I allow of course that return of sensation may be due to nerve regeneration, but do not think that it often is.

The only advantage I see in the removal of a piece of nerve rather than simple division of the same, is that, in the former operation, various branches may also be divided—*e.g.*, in excision of the infra-orbital nerve, the branches to the teeth and gums will be severed, whereas simple neurotomy at the infra-orbital foramen will yet permit of sensations being conveyed to the irritated centre from the teeth, gums, and lip.

Neurotomy has this advantage over both neurectomy and nerve-stretching: it can be performed in many cases subcutaneously, and thus the operation will be less formidable to the patient and less of a scar will result. The objection to this treatment is that, in case of failure, the operation of nerve-stretching cannot be efficiently performed at a future time. Personally, I should always prefer to stretch the nerve in any case in which I considered an operation advisable at all, for in case of failure or return of pain, either the same operation may be repeated, or neurotomy or neurectomy may be performed. For my own part, I should not expect success from either of the latter operations where the former had failed.

The following cases are good examples of the effects of operative interference in cases of facial neuralgia :

Billroth.—Neurectomy for Facial Neuralgia of the Inferior Dental Nerve.*

A man, aged forty-three, had suffered from neuralgia for ten years. A portion of the inferior dental nerve was resected. A few days later there was severe arterial hæmorrhage which necessitated ligature of the right common carotid. Six months later he was strong, and had no further neuralgic attacks.

Grant.†—Neurectomy of the Inferior Dental Nerve for Neuralgia.—Cure.

The patient was a woman, aged forty-five, who had suffered from neuralgia for twenty-three years. Almost all the teeth had

* *Clinical Surgery*, p. 58.

† *Lancet*, July 11, 1885, p. 61.

been removed, but without relief. The pain was situated in the region of the left inferior dental nerve. On Feb. 25th an operation was performed, the masseter muscle was divided, the ramus of the jaw was trephined, the inferior dental nerve was stretched, and finally two and a quarter inches of it were removed. Three months later there had been no return of pain.

Weir Mitchell.—Dental Neuralgia.—Neurectomy of the Inferior Dental Nerve.—Recurrence of Sensation without Reunion of the Nerve.*

“A lady, aged forty-three, who had suffered from severe dental neuralgia for many years, underwent, in April 1881, the operation of resection of the left inferior dental nerve. A year later the pain returned at the old place, and in June 1882 it became as bad as before. On close study it was found that sensation had been restored in the area where it had previously been lost. On June 28th the bone was exposed, a trephine was applied an inch and a quarter in front of the angle of the jaw, but we could find no nerve. The old trephine hole had filled up with bone, except for an opening about one line wide, from which projected a button-like prominence which proved to be a stump of nerve-tissue. On trephining so as to include it we failed again to find the filament running along the irregular canal, which certainly existed. The operation enabled us to pull out the nerve-trunk some distance, and after stretching, to sever it. A more careful search was made for the filament presumed to have been connected with the sensitive skin on the chin; but finding none, the canal was cleaned out, and the two ends were thoroughly filled with dental cement. May 10th: There has been a recent return of neuralgic pain.”

[No note is made of the effect of this later operation on the anæsthesia of the chin.]

Billroth.†—Neurectomy of Supra-orbital Nerve for Facial Neuralgia.

The patient was a woman, aged nineteen, whose left eyeball had been removed a year previously, and a right iridectomy had been performed for glaucoma. For seven weeks she had had intense but not continual pain in the track of the right frontal nerve. This nerve was divided, and the pain in the forehead

* *American Journal of Medical Science*, vol. lxxxvi. p. 17.

† *Clinical Surgery*, p. 58.

ceased, but became subsequently much more intense in the right eyeball, and in the track of the right supra-maxillary nerve. The pains were alleviated, but not entirely removed.

Billroth.—Neurotomy of the Infra-orbital Nerve for Neuralgia.*

A man, aged forty-six, had for twelve years suffered from neuralgia of the right infra-orbital nerve. The attacks, which were accurately limited to the distribution of this nerve, were excited by touching the cheek with the tongue, by eating, pulling the beard, &c. In July 1863 the infra-orbital nerve was divided subcutaneously at several points. From this time he was free from his attacks, his cheerfulness returned, and he was able to resume his avocation. This relief lasted one and a half years, then slight pain in the nose began. In Feb. 1866 the patient returned, stating that his complaint was more an inconvenience than a disease, but he desired that nerve section should be again performed that he might be rid of the trifling attacks. In Feb. 1867 the nasal branch of the infra-orbital was divided subcutaneously. In July 1867 he remained completely free from attacks.

Billroth.†—Neurectomy of the Infra-orbital Nerve for Facial Neuralgia.

A man, aged fifty-three, had suffered from pain for twelve years over the distribution of the second division of the fifth. In May 1872 subcutaneous division was performed on the nerve at its exit from the infra-orbital canal. Four months later the pain returned. In Nov. 1873 the operation was repeated. He recovered, but recurrences again took place in three months. In March 1874 the whole infra-orbital nerve was resected. The patient wrote three years later to the effect that his pain had not altogether disappeared, but his condition was materially improved.

Cadge.‡—Section of the Infra-orbital Nerve for Facial Neuralgia.

A man, aged forty-seven, suffered from neuralgia of great intensity and of nine months' duration in the parts supplied by the

* *Clinical Surgery*, p. 58.

† *Ibid.*

‡ *British Medical Journal*, July 15, 1882, p. 83.

infra-orbital nerve. This nerve was divided on Nov. 28, 1872. The relief was immediate and complete, and the immunity lasted nearly a year. Then pain recommenced and became severe. On Nov. 25, 1873, the nerve was again divided. The effect was not so immediate. He had pains and spasms for a few days, then they ceased entirely and he was quite well again. Until June 1875 he had no return. Then he had severe pain, and on Oct. 26th the same nerve was again divided. The relief was not marked, as pain continued for a month, and only ceased after injection of morphia and atropine. He died in 1880, and had recurrences of pain until his death.

Weir Mitchell.—Facial Neuralgia.—Neurotomy of the Infra-orbital Nerve.—Cure.*

Mrs. M., aged sixty-eight, had for some years suffered with neuralgia of the face affecting the region supplied by the supra- and infra-orbital nerves. The infra-orbital nerve was alone divided, but the results were to annihilate pain in all branches of the fifth nerve.

Cadge.†—Division of the Supra- and Infra-orbital Nerves.

The patient was a man, aged forty-six, who had suffered from extremely severe facial neuralgia. In Nov. 1873 the supra- and infra-orbital nerves were divided, with no immediate effect, but in a week or two the pain left him and did not return for nearly a year, and then not so badly as formerly.

Cadge.‡—Division of the Supra- and Infra-orbital Nerves.

A lady, aged seventy-eight, had suffered from facial neuralgia for seventeen or eighteen years. On July 6, 1881, both infra-orbital and supra-orbital nerves were divided. The pain was relieved so far as the frontal was concerned, but continued along the course of the infra-orbital. A fortnight later the infra-orbital was again divided, and more freely, there having been some doubt as to whether it had been divided on the first occasion. The relief was complete, and for ten months there was no return of pain, though there was some of sensation.

* *American Journal of Medical Science*, vol. lxxxvi. p. 17.

† *British Medical Journal*, July 15, 1882, p. 83.

‡ *Ibid.*

Morton.—Excision of the Trunk of the Infra-orbital Nerve for intense Neuralgia of fifteen years' duration.—Partial Success.*

A gentleman, aged sixty, had suffered from severe neuralgia of the left side of his face for fifteen years, which had resisted all treatment. In May 1870 the infra-orbital branch of the left side was excised, the antrum being trephined, and fully an inch of the nerve removed from a point as far back as possible. Total anæsthesia of the side of the face followed, with absolute relief from the neuralgia. On March 16, 1871, the patient's brother wrote to us that relief was entire for three months, but that since that time the patient had suffered from some pain in the lips and in the lower part of the face. This condition continued till Jan. 1873.

Morton.†—Excision of the Trunk of the Infra-orbital Nerve for Neuralgia of thirty years' duration.

A lady, aged sixty-one, who had suffered from severe facial neuralgia for thirty years, was operated on in June 1871, the whole of the infra-orbital nerve to the length of an inch and a quarter being removed. Until Aug. 12, 1873, the patient remained absolutely free from all pain. There was also a complete restoration of sensation on the left side where the nerve was excised.

Nicaise.‡—Excision of the Infra-orbital Nerve for Neuralgia. Cure.

A man, aged forty-four, had suffered for many years from neuralgia of the face. The greatest pain was on the level of the infra-orbital notch and in the neighbourhood of the molar teeth. As all medicinal treatment had failed, the infra-orbital nerve was stretched, and a portion of it cut out from the infra-orbital canal. Three weeks later the patient remained perfectly well.

Sée.§—Stretching of the Inferior Dental Nerve for Neuralgia.—Cure.

The patient was a woman, aged forty-seven, who had suffered from severe neuralgia for six years. The pain was situated chiefly on the alveolar border of the left lower jaw and radiated to the tongue and cheek. These pains were at first intermitting, but had

* *American Journal of Medical Science*, vol. lxvi. p. 392. † *Ibid.*

‡ *Gazette des Hôpitaux*, 1881, p. 1123. § *Revue de Chirurgie*, 1882, p. 602.

become continuous for two years, and rendered life miserable. As all medicinal treatment had failed, the operation of stretching the inferior dental nerve was undertaken, an incision being made, according to Sonnenberg's method, along the posterior border of the ascending ramus of the jaw. The pains were cured, but for how long is not mentioned by the author.

Monod.—Stretching and Tearing-out of the Inferior Dental Nerve for Neuralgia.—Cure.*

A man, aged fifty-four, had suffered from severe attacks of facial neuralgia for nine years subsequent to an exposure to great cold in a snowstorm. On July 18, 1882, the inferior dental nerve was stretched after trephining the lower jaw. The operation gave relief for six months, but at the end of that time the pain recurred. On May 22, 1883, the mental branch of the inferior dental was exposed, the lower jaw was again trephined, and that portion of the nerve which lies in the inferior dental canal was completely torn out. In July 1884 there had been no further return of neuralgic pain.

Monod.†—Avulsion of the Inferior Dental Nerve for Neuralgia.—Cure.

M., aged seventy-nine, with good family history, and himself healthy, had suffered from facial neuralgia for three years. All medicinal treatment failed to procure relief. On May 19th the mental branch was exposed by an incision along the border of the lower jaw joining a vertical incision through the lower lip. The lower jaw was then trephined, the centre of the trephine hole being one centimetre to the outer side of the mental foramen and eight millimetres from the border of the lower jaw. The dental nerve was then seized, and three and a half centimetres of its length were torn out. Seven weeks later the pain had not returned.

Sée.‡—Stretching of the Inferior Dental Nerve for Neuralgia. Recovery.

A lady, aged forty-seven, had for six years suffered from severe facial neuralgia. For this there was no known cause. The pain was referred to the left cheek and gums and the left side of the

* *Bull. et Mém. de la Soc. de Chir. de Paris*, 1884, vol. x. p. 580. † *Ibid.*

‡ *Ibid.*, 1882, vol. viii. p. 448.

tongue. At first intermittent, the pain had of late become almost constant, the patient was unable to sleep, and was in a highly nervous state. All medicinal treatment had failed. On March 9, 1882, the inferior dental nerve was stretched after Sonnenberg's method, an incision being made below the lower jaw extending from the angle to the facial artery. The nerve was reached by stripping the internal pterygoid muscle off the jaw. The operation wound healed well, and for three months there was no return of the pain.

Brailey.—On Stretching of the Supra-trochlear Nerve.*

Brailey records six cases in which he performed this operation. In every case the operation was undertaken for the relief of pain occurring in connection with glaucoma. In two cases the pain was entirely relieved. In one the pain was entirely relieved for a month, but then recurred, although not so severely. In one, in which the supra-orbital was stretched as well, there was no relief to pain. In one pain was relieved for five days, but after that it was as bad as ever. In one there was improvement, but at no time entire removal of the pain. In all six cases the stretching of the nerve was followed by diminution in the ocular tension.

Stretching of the Nasal Nerve for Orbital Neuralgia.—Success.

Badal† (reported by Trélat) reports three cases in which the nasal branch of the ophthalmic was stretched for persistent neuralgia of the orbit, and with complete success. The nerve was stretched close to its exit from the orbit. The patients were aged thirty-three, twenty-three, and sixty-seven years.

The above cases are sufficient in number to show that the operations of neurotomy, neurectomy, and nerve-stretching may all be of avail in cases of neuralgia of the face. To quote more cases would be tedious, for the similarity of each case to the other is great, and no advantage is gained by simple repetition.

The prognosis in cases of operation is very difficult. I believe that it may be pretty confidently asserted that *relief* is most likely to follow, but may be only transient. Statistics do not suffice to tell in what proportion of cases operated upon a *final cure* results, for in most reported instances a sufficient length of time has not

* *British Medical Journal*, 1885, vol. ii. p. 688.

† *Bull. et Mém. de la Soc. de Chir.*, 1882, p. 823.

elapsed to allow of a definite answer being given. In addition, in all statistics hitherto compiled cases of epileptiform neuralgia have been mixed with those of the less severe and less intractable variety, and I therefore do not think that anything is to be gained by quoting from the various statistical tables. Neither do I consider that anything is to be gained by gathering the published cases of simple facial neuralgia treated by operation, for it is very manifest that only the more successful find their way into print, and such a collection would be misleading. My own personal experience of cases treated by operation is not sufficient to allow me to draw any deductions, and for the present, therefore, I am reluctantly obliged to confess my inability to give any satisfactory prognosis. I think that the chances of temporary relief are good, and that in a considerable number of patients a permanent cure may result.

Nerve-stretching for Non-traumatic Neuralgia of the Extremities.—*The Upper Extremity.*—Idiopathic neuralgia of the upper extremities is a rare affection, but cases where the pain has followed an injury are more common. Of the latter I have treated when dealing with Traumatic Neuralgia.

Three cases of the former have been recorded by Langenbuch,* in each of which stretching of the brachial plexus gave but little relief.

In a case recorded by Hildebrandt,† the patient, a man aged thirty-two, complained of pain in the arm and forearm, with stiffness of the fingers. The brachial plexus was stretched, and the patient obtained immediate and permanent relief.

In the following case the patient was not only not benefited by the operation of stretching the brachial plexus, but a permanent paralysis of the ulnar nerve was set up. In all probability the pain was really central, and operative procedures on the extremity did not exercise any influence on the seat of the mischief:

Neuralgia of the Shoulder and Arm.—*Excision of Shoulder-joint.*—*Stretching of Brachial Plexus.*—*Neuritis followed by Paralysis of Ulnar Nerve, with Wasting.*

T. B., a sailor, aged forty, and a healthy man, was admitted into St. Bartholomew's Hospital, in 1880, on account of extreme pain in the shoulder-joint. His past history was good, except

* *Deut. Med. Woch.*, No. 19, 1880.

† Quoted by Fenger and Lee.

that he had had dysentery twenty years ago, and that twenty-five years previous to admission he had sustained a fracture of the vertex of the skull, followed by temporary paralysis of the right leg. A few months before admission he fell off an omnibus and struck his right shoulder. Since then it had been painful and stiff. On admission there was found to be stiffness and pain in the right shoulder, but none of the objective signs of inflammation. He complained of constant darting pains in the joints. He was treated at first by rest and strapping. After three years' treatment of various kinds, Mr. Savory was induced as a last resource to excise the head of the humerus in the hope of relieving him from the pain from which he suffered. The articular cartilage was found healthy, and the condition of the joint did not appear sufficient to account for the pain, although there was a little thickening of the synovial membrane. The operation did not appear to relieve him in any material way, and in Feb. 1884 he again applied for relief from the pain, which extended down the whole of the forearm and hand, and was of a neuralgic nature. On this occasion he was under the care of Mr. Marsh, and after consultation with other surgeons the brachial plexus was stretched in the axilla. The pain continued, and for three months galvanism was tried. He left the hospital unrelieved on April 21st. In Jan. 1885 he again returned, his arm was much worse since the last operation. The muscles of both the upper arm and forearm were wasted. The hand was flat and shapeless, the arm was kept close to the side, the forearm was semiflexed. The hand was pronated, and the fingers stiff and straight. From this position he could not move the parts except with the aid of the other hand. The elbow, wrist, and finger-joints were all very stiff and apparently partly ankylosed. He complained of constant tingling sensation in all the parts supplied by the internal cutaneous, intercosto-humeral, and ulnar nerves, and pain was increased as these parts were touched. There was loss of cutaneous sensibility, especially in the ulnar distribution, and pain on pressure along the course of the ulnar nerve. The skin of the fingers was tense, shiny, and glossy. He said the hand felt longer than it really was. Electrical examination: There was no reaction at all of any of the muscles supplied by the ulnar nerve, while those supplied by the median reacted feebly. The extensors acted normally. The patient was extremely anxious for amputation at the shoulder-joint, but as it was not believed

that this would benefit him the operation was not performed, and on Feb. 7th he again left the hospital.

The next case by Weir Mitchell is a very curious one, and, to the best of my knowledge, stands by itself:

Weir Mitchell.—Peculiar Nutritive Changes on Palm and Back of Hand.—Neuralgia.—Stretching of Median and Radial Nerves.—Improvement.*

“ A woman, aged forty, first came to the Hospital for Nervous Diseases in Nov. 1880, with the history that ten years ago she noticed a numbness in the palm of the right hand when milking the cows, though six months later she also observed it during ironing. Succeeding this numbness pain made itself manifest, affecting the palm and all the fingers of the hand. The condition grew gradually worse until two years ago she was unable to make use of the hand on account of the suffering. The trouble was most apparent in the morning when first awakening, and was increased both in extent and intensity by cold, whilst warmth or pressure in a measure relieved it. On examination the pain was found to be located in the palm between the second and third metacarpal bones, and to extend through to the dorsal aspect of the hand. There was no pain elsewhere, nor did pressure along any of the nerve tracts disclose any painful spot. Sensation to touch appeared normal; the muscles were firm and well developed, though not so strong as in the other hand. There was no muscular atrophy, no contractions, and no joint disease or glossy skin; the nails also were natural. Some three months ago an herpetic eruption made itself apparent on the back of the affected hand, otherwise she was in excellent general health. Strychnia was prescribed, and in April 1881 she returned reporting considerable improvement; the eruption had, however, become a distinct eczematous sore. She was treated by galvanism and arsenic, with the result that the pain in the hand lessened so considerably as to cause but little trouble, whilst the sore on the back of the hand healed. In August she became worse, and a small abscess formed on the back of the hand between the first and second metacarpal bones. Following this, a second abscess appeared on the inner side of the forearm, and a third in the palm. In addition to these, other abscesses developed from time

* *American Journal of Medical Science*, vol. lxxvi. p. 17.

to time in the forearm and the back of the hand. At no time had she any abscess above the elbow. Galvanism was persisted in for a long period, but as it did not afford any permanent relief I advised that one or both of the nerves supplying the affected part—the median and the radial—should be stretched, and she entered the hospital on Feb. 9, 1882. On March 9th the median nerve was stretched, and by the fifteenth day the wound was entirely healed. Two hours after the operation the temperature of the right hand was two degrees higher than that of the other. Four days later a careful examination disclosed an increased area of anæsthesia, the loss of sensation apparently including part of the radial distribution. There was little of the former pain, but some sense of numbness. Within the third week the pain recurred with all the former severity, and for the next month she had neuralgia as severe as before. On May 16th a small ulcer appeared on the back of the hand, and, as matters grew worse rather than better, on June 14th the radial nerve was stretched one and three-quarter inches above the wrist. The wound healed rapidly. At present (Nov. 16th) she is much improved in her general appearance, and since the last operation has had no eruption on the back of the hand nor any severe pain through the palm; there is, however, a nearly constant aching in the fleshy portion of the hand increased by use."

The Lower Extremity.—Idiopathic neuralgia of the lower extremity almost always affects the sciatic nerve. Why this nerve should be so frequently selected it is difficult to say. It is certainly not so frequently exposed to cold or injury as the nerves of the leg, yet the tibial and peroneal nerves are hardly ever the seat of neuralgic pain.

With regard to the exciting causes and the general treatment of sciatica I have nothing to add to that which I have already written on this subject whilst discussing the treatment and causes of neuralgia in general, but it is to this form of neuralgia more especially that the operation of nerve-stretching has proved beneficial.

I do not propose to detail any of the many recorded cases. They possess so great a similarity that such a task would be a useless repetition. Upwards of a hundred have been published, and the statistics of Omboni show 117 cases: 83 cures, 24 improvements, 9 failures, and 1 death.

I do not accept this as a true indication of the success of the

treatment, and should not expect so large a percentage of successful cases were all operations published. Nevertheless, the treatment is one that holds out great prospects of relief, and, in my opinion, should be adopted in those cases in which all other treatment has failed.

It should be remembered that the sciatic nerve can be very efficiently stretched without any incision, and, except when the patient is old and the other tissues—especially the vessels—are weak and lacerable, I would always stretch subcutaneously, and thoroughly knead the sciatic nerve before proceeding to expose it by an incision. I have seen several patients entirely cured by this means, and am of opinion that it is one of the most valuable methods of treatment of sciatica. It can readily be repeated if necessary, and, in case of failure, stretching by incision always remains as a last resort.

The operation of neurotomy or neurectomy of the sciatic is quite unjustifiable as a means of treatment of sciatica.

Nerve-stretching for Intercostal Neuralgia.—It can very seldom happen that intercostal neuralgia, independent of other morbid conditions, can be sufficiently severe to necessitate the operation of nerve-stretching. Nevertheless, the intercostal nerves have been stretched on several occasions for the relief of neuralgic pain. The first operation of the kind was performed by Nussbaum in 1878 on a man, aged twenty. The eighth, ninth, and tenth intercostals were stretched, and, for a time, the pain ceased, only to return as severely as before after a short interval.

In 1880 Keleff* reported another case in which a cure followed stretching of the fourth, fifth, and sixth intercostals.

Another case operated upon in 1873 is mentioned by Artaud and Gilson. The patient was a young man, aged twenty-one. The operation afforded no relief.

In the *Revue des Sciences Médicales* for October 1885 will be found the details of another patient operated upon by Lesser. She was a woman, aged sixty-one. The intercostal nerves on the right side from the fourth to the tenth were stretched. The wound healed well, and there was no return of pain until the time of the patient's death, four months later. The cause of death is not stated.

* *Wiener Med. Woch.*

CHAPTER XXIV.

**SURGICAL TREATMENT OF EPILEPTIFORM
NEURALGIA.**

I HAVE separated epileptiform neuralgia from cases of simple facial neuralgia, because of the much greater severity and obstinacy to treatment presented by the former.

On account of these characteristics such patients are far more likely to come under the care of the surgeon than are those who suffer from the milder form of the disease.

As I have already mentioned, in describing the symptoms of epileptiform neuralgia, attacks are frequently brought on by peripheral irritation of all kinds, and what I have written as to the effect of peripheral irritation and an abnormally excitable condition of the nerve-centres holds good for epileptiform as for the other variety of facial neuralgia.

These cases, indeed, bear a very strong resemblance to cases of epilepsy caused by traumatism, but unfortunately do not yield so readily to surgical interference.

On account of the extreme severity of the pain, the patients are, as a rule, only too willing to undergo any operation which holds out the slightest prospect of relief, and, in considering the advisability of operating in any given case, it should be borne in mind that the sufferer may be quite willing to purchase even temporary immunity at the expense of almost any surgical operation.

In any case, therefore, of epileptiform neuralgia which had failed to yield to ordinary remedies, I should advise operation on that branch of the fifth nerve to which most of the pain was referred. The operation I would prefer would be that of nerve-stretching, and for the reasons already assigned.

I do not think that an altogether satisfactory prognosis should ever be given. I believe that, as a rule, some temporary benefit may at least be expected. In most cases the pain ceases for some

weeks, and perhaps months, after operation, and, in yet others, a permanent cure is effected.

The following cases afford at once illustrative examples of epileptiform neuralgia, and of the effects produced by nerve-stretching :

Grainger Stewart.—A Case of Epileptiform Neuralgia treated by Nerve-stretching.—Cure.*

The patient was a man, aged seventy, a station-master. He had been perfectly healthy till the year 1862, when he was seized with facial neuralgia. At first the pain was of a burning character, but gradually increased in severity, the paroxysms becoming as time went on more frequent and intense, until at last his life was almost intolerable for him. Indeed, had it not been for the remissions, during which time the pain was easier, and the periods of immunity, during which he was perfectly well, it would have been so. These periods of immunity varied in length—sometimes six weeks, sometimes three months, and on one occasion a whole year. But, sooner or later, the attacks returned, and for six or eight weeks he had little freedom. The attack from which he was suffering at the time of his admission had lasted from the end of April, and showed no signs of abatement up to the time he was seen. When a paroxysm occurred, his face would suddenly change; twitching of its muscles on the right side set in, leading to the strangest grimaces. The paroxysms might recur almost immediately or not for hours—generally they were most severe in the evening and during the night. They were easily induced by touching the skin or pulling the hair of any part of the area of distribution of the affected nerve, or by touching the gums or tongue. Mastication had thus become impossible, and all food had to be taken in a liquid form. Nine of the teeth had been extracted in the hope of obtaining relief, but without benefit. The case afforded a typical example of the malady described as epileptiform neuralgia. The pain was most intense in the lines of distribution of the right infra-orbital nerve. On Oct. 22nd the infra-orbital nerve was exposed and stretched as vigorously as its size seemed to warrant. In the course of that day there were several severe attacks, and for some time the pain occasionally recurred, but it speedily abated, and for a

* *British Medical Journal*, 1879, vol. i. p. 803.

month thereafter there was almost complete immunity. At the end of that time the paroxysms returned, and on Nov. 28th another attempt was made to stretch the nerve. In consequence of the matting of the tissue in the cicatrix the nerve was cut through, and the parts became anæsthetic for the time. Still the pain continued, and it was soon clear that little or nothing had been gained by the second operation. However, on examining the patient closely, it was found that the points of origin and of maximum intensity of the pain were different from what they had been at first, and that the pain now mainly originated in the mental branch of the third division of the fifth instead of in the labial branch of the middle division. On Dec. 18th the mental nerve also was stretched (by Dr. Bishop). The operation afforded instantaneous relief, and was followed by five months' complete immunity from pain. Since that time the patient has not been heard of.

Polaiillon.—Stretching of Inferior Dental Nerve for Neuralgia.
Success.*

A man, aged sixty-one, came into the hospital on August 2nd. For three years the patient had suffered from neuralgia in the left lower jaw and lip. The paroxysms of pain were constantly recurring (almost every five minutes), and were excited by the least attempt at deglutition or speaking. Pressure on the point of emergence of the supra- or infra-orbital nerve, or of the mental nerve, excited a paroxysm. The pain was not accompanied by any spasm of muscles. After some improvement under medicinal treatment the inferior dental nerve was stretched on Sept. 6th. The nerve was reached by an incision of a rectangular shape along the ramus, angle, and body of the lower jaw, and the masseter muscle was stripped from the jaw, the bone trephined, and the nerve exposed.

Sept. 7th.—There is no loss of sensation.

8th.—No return of pain.

10th.—An attack of pain at ten o'clock in the morning.

12th.—Repetition of pain.

13th and 14th.—Further attacks of pain.

Nov. 6th.—The patient wrote to say that he was in a satis-

* *Soc. de Chir.*, 1881, vol. vii. p. 802.

factory condition, that he had had no pain for fifteen days and was well content, that he could work all the day and sleep well at night.

Morton.—Neuralgia of Face.—Inferior Dental Nerve Stretched.
Cure.*

A man, aged seventy-one, had for nine years suffered from neuralgia of the lower jaw, recurring at short intervals, and being caused by any movement or irritation of the mouth. All remedies had been tried without relief, and several teeth had been removed. During the last few years he had been unable to eat or to sleep. On March 21st an operation was performed. The jaw was trephined, and the inferior dental nerve was drawn forward on a hook, thoroughly stretched, and half an inch excised. In a fortnight he was well. Six weeks later he had had no return of the pain.

Whitehead.†—Nerve-stretching in Epileptiform Neuralgia.—Success.

In this case the inferior dental nerve was stretched on Dec. 7, 1884, and the patient considered that the pain was much mitigated by the operation. Five drops of tincture of gelseminum were then given for some weeks. The pain entirely ceased, and notwithstanding that all treatment had been suspended for four weeks there had been no recurrence when the patient was last seen.

Buzzard.‡—Nerve-stretching for Facial Neuralgia of an Epileptiform Type.—Improvement.

The patient was a man, aged fifty-six, who was admitted, on June 26, 1880, to the Hospital for Epilepsy, for neuralgia of the supra- and infra-orbital divisions of the fifth nerve. Ten years previously he had been attacked with sudden pain in the right side of the forehead. At first he had recurrence of pain once or twice a week, but in the course of a few months the attacks became almost continuous for a period of three weeks. After this he had a respite for twelve months; then an attack lasting

* *Philadelphia Medical Times*, vol. ii. p. 598.

† *British Medical Journal*, 1885, vol. i. p. 1102.

‡ *Ibid.*, 1883, vol. ii. p. 1126.

about three weeks, followed by an interval of a year; then another attack, and an interval of eight months; then a seizure, lasting eight or nine weeks, and a respite of about twelve months; then an attack which lasted three months. Since that seizure, which occurred two years before his coming under notice, he had never been entirely free from pain. The pain was excited by speaking, laughing, yawning, swallowing, or closing either of the eyes, and would occur also spontaneously and independently of any movement. The case appeared to be one of epileptiform neuralgia. On July 5, 1880, Mr. Adams stretched the right supra-orbital nerve. Four days after the operation there was a slight diminution of pain. On July 28th, as there was some pain, the infra-orbital nerve was stretched. This operation was followed by a week of almost complete immunity from pain. He remained free from any attack until Sept. 1st, when it returned in the forehead. It now began to recur four times a day, and on Oct. 13th he was re-admitted. The right supra-orbital nerve was again stretched. The operation was not followed by relief immediately, though on Oct. 20th there was distinct improvement. On Jan. 4, 1881, the supra-orbital and infra-orbital nerves were again stretched, and afterwards divided. A certain amount of relief followed until Jan. 25th, when the pains returned as severely, but not so frequently, as before the operation. On Feb. 14th Mr. Adams made an incision along the right side of the nose, and stretched all the tissues down to the periosteum. In the evening the patient had a rather severe attack, beginning in the gums, and two such seizures in the night. On March 14th he reported that he had been free from pain. On April 3rd he had only to speak of a few slight pricks of pain now and then, and could eat without suffering. In July 1882 the patient returned to report himself. For one year after leaving the hospital he was very much better. He had returned to work, and had since continued at it. In the old days an attack would last six or eight weeks; latterly, although he continued to be attacked, the pain did not last so long, and was much less acute.

Buzzard.—Nerve-stretching for Facial Neuralgia.*

A man, aged thirty-four, was admitted into the Hospital for Epilepsy, on June 1, 1881, with the history that one day in 1874,

* *British Medical Journal*, 1883, vol. ii. p. 1126.

whilst washing his face (which was perspiring freely) with cold water, he suddenly felt a sensation like a bad tooth. This had continued ever since, and tended to grow worse. Treatment had no effect. He had attacks of screwing pains in the right infra-orbital nerve passing backward to the front of the ear and up that side of the head. The pain sometimes came down to the mental branch, and then it felt as though all his teeth were aching. He also had pain sometimes in the roof of the mouth and in the right upper gum. The pain was brought on by eating and drinking, and by cold air. He had had during the previous month, every day without exception, about fifteen attacks in the twenty-four hours. On July 4th Mr. Adams stretched the infra-orbital nerve. Three days afterwards the patient said that he had had no pain at all in the infra-orbital region since the operation, and that he had not been so free from pain for seven years. On July 13th he complained of two or three slight sensations of pain just outside the right ala of the nose. A week later, in consequence of pain in the mental branch of the fifth, Mr. Adams cut down on this nerve and stretched it. Next day there was anæsthesia of the right lower lip. For three months after this operation the patient continued free from pain. On Nov. 28, 1883, it was reported that he was still suffering from neuralgia, the pain both in the face and cheek being as severe as before the operation, but never going to his forehead.

Walsham.—Epileptiform Neuralgia treated by Stretching the Infra-orbital Nerve.*

A woman, aged fifty, was admitted into the Metropolitan Free Hospital, on Jan. 23, 1880, with well-marked epileptiform neuralgia, chiefly confined to the infra-orbital part of the fifth nerve of the right side. The neuralgia commenced ten years before admission. The attacks never lasted more than a few seconds at a time, and at first occurred only at distant intervals. Occasionally she had had intervals of complete cessation for several months. The intervals became shorter, and the attacks more frequent. In Oct. 1867, she was confined to bed for six months, and at this time had numerous teeth extracted. The

* *British Medical Journal*, 1880, vol. ii. p. 1009.

following year she was again confined to bed on account of the pain. In spite of all treatment the attacks got worse. The pain was excited by swallowing food or hot or cold fluids, washing the face, or exposure to the least current of air. Slight pressure over the supra- or infra-orbital foramen, or on the gums, or pinching the lip or cheek was sufficient to bring on an attack. Each attack began in the upper lip and spread to the side of the nose, thence proceeding to the lower eyelid.

Feb. 3rd.—The infra-orbital nerve was stretched.

5th to 11th.—She had an attack of facial erysipelas. Five months after the operation there had been no return of pain.

Polaillon.—Stretching and Avulsion of the Inferior Dental Nerve for Epileptiform Neuralgia.—Cure.*

M. S., aged sixty-eight, a plethoric man, had suffered from severe facial neuralgia of an epileptiform character for three years. The pain was always situated on the right side of the face, and especially in the right lower jaw. After two years' pain, a lower molar tooth, which was found to be quite healthy, was withdrawn. From this time onward the least touch of the gum at the site of extraction, whether by the tongue or by food, brought on the most violent paroxysms of pain, often lasting twenty minutes or more. After various treatment an operation was undertaken on Jan. 5, 1882. An incision was made along the lower border of the inferior maxilla, and extended along the posterior border of the ramus, the dental canal was exposed, the jawbone was trephined, and finally, after thorough stretching, as much as possible of the dental nerve was dragged away from the dental canal. After the operation the patient had on several days some return of pain, but two months later expressed himself as being almost "in paradise," being able to eat, sleep, and talk without suffering.

Epileptiform Facial Neuralgia.—Stretching of the Inferior Dental Nerve.—Recovery.

Mouchet (reported by *Polaillon*).†—A lady, aged thirty-eight, of good health, had suffered from severe facial neuralgia for twelve

* *Bull. et Mém. de la Soc. de Chir. de Paris*, 1882, p. 450. † *Ibid.*, 1883, p. 119.

years; the pains dated from a time when she lived in a very cold, damp house. The attacks of neuralgia were intermittent, and lasted from three weeks to three months. During this time the patient had constant paroxysms of pain every few minutes, and lasting for two or three minutes each. Speaking, eating, or a breath of air were enough to start a paroxysm. The pain was on the right side of the face, and generally radiated from the lower jaw. It was accompanied by spasm of the buccinator and orbicularis-oris muscles. On Feb. 24, 1883, the inferior dental nerve was stretched. The operation consisted in making an angular incision opposite the angle of the jaw, exposing and reflecting upwards the masseter muscle, and then trephining the ascending ramus two centimetres below the sigmoid notch. The dental nerve then came into view, and was strongly stretched. The wound healed slowly, as the process was interrupted by an attack of erysipelas. The pain, however, did not recur, and four months after operation the patient continued well, except for some difficulty in mastication.

*Epileptiform Neuralgia.—Inferior Dental Nerve Stretched.
Slight Improvement.*

Longuet (reported by Chauvel).^{*}—A man, aged forty-one, who had suffered for four years from facial neuralgia of an epileptiform type, applied for relief at the Hôtel Dieu, on June 16, 1882. The neuralgic pains began in the gum of the right lower jaw, opposite to the first bicuspid tooth. From there they spread to the cheek and chin. They were brought on by eating, speaking, or by any violent expiratory effort. They constantly occurred at night. The attacks lasted from fifteen to thirty minutes, during which time the patient lost all control over his movements. During the attacks there was always twitching of the right side of the nose and the right angle of the mouth. On July 4th the inferior dental nerve was stretched from within the mouth. The operation, which was done without anaesthetics, was followed by immediate relief from pains and by anaesthesia of the mucous surface of the lower lip and gum. There was no anaesthesia of the skin. By the seventh day the anaesthesia had passed off, and at the end of a month the pains again recommenced, but were not accompanied by the spasmodic twitching previously noted.

^{*} *Bull. et Mém. de la Soc. de Chir. de Paris*, 1883, p. 77.

Le Dentu.—Epileptiform Neuralgia of the Face cured by Stretching the Lingual Nerve.—Cure.*

The patient was a woman, who suffered from severe pains of a neuralgic nature in the temporal region in the cheek and in the ear of the left side. The lingual nerve was stretched from within the mouth, and at the time when the case was reported—thirteen days later—there had been no return of the pain.

Polawillon.†—Epileptiform Neuralgia cured by Stretching the Lingual Nerve.

The patient was a man who for three years had suffered from neuralgia of the fifth nerve, affecting particularly the tongue and the left side of the lower jaw. The nerve was stretched from within the mouth, and the operation was followed by immediate relief. Four days later, however, there was some return of the pain, and after this the patient became gradually free from further trouble, and remained well until the time at which the case was reported—two months after the operation.

It will thus be seen that in all these cases the operation of nerve-stretching was followed by relief, and in most of them there was no return of the symptoms. It must, however, be pointed out that in none of them had a sufficient amount of time elapsed to warrant the statement that the cure was a permanent one, the average time, indeed, which had passed between the operation and the last report being only about three months and a half. Unfortunately, this objection holds good for almost all the cases hitherto reported, and renders conclusions very difficult to draw, and this difficulty is enhanced when we find that cases of epileptiform neuralgia are not usually separated from the other and more amenable class of neuralgias.

The important fact, however, remains, that the operation usually procures some relief at least, and, even when it fails to promote a cure, it, at any rate, mitigates the suffering, and if this alone were effected most patients would willingly submit to the performance of an operation which can scarcely be classed as serious.

* *Revue de Chirurgie*, 1881, p. 1030.

† *Ibid.*, p. 1031.

There remain, however, unfortunately many cases in which the operation of nerve-stretching either fails entirely or else gives but little relief, and the question at once arises if anything more can be done. As I have already said in a previous chapter, the operation of neurotomy really holds out no reasonable hope when nerve-stretching has failed; but, on the other hand, the removal of a considerable portion of a nerve is undoubtedly most useful in some cases where both neurotomy and nerve-stretching have proved useless, and there are many recorded cases of improvement and of success after this procedure. The rationale of neurectomy I have already endeavoured to explain, and will now only recall the fact that the operation is likely to be useful in proportion to the length of nerve removed, so that if the surgeon decide on excising a portion of one of the branches of the fifth, he should make up his mind to remove as much as can be reached.

Excision of Meckel's Ganglion.—The excision of Meckel's ganglion is to be looked upon as an operation whose object is not merely the removal of the ganglion, but the obliteration of the whole of the superior maxillary trunk, and is a neurectomy of the class most likely to prove beneficial, for it aims at the removal of a considerable length of nerve.

Although originated many years ago, excision of Meckel's ganglion has not been frequently performed, and has met with very little support in England. The operation, however, is not so difficult as it sounds, and the results obtained are quite sufficiently good to warrant the small risk involved. An excellent summary of the cases recorded up to date has been published by Dr. Fowler, in the *Annals of Surgery* for 1886 (vol. i. p. 269), and from the tables he adds I have extracted the following twenty-six cases, which include all which were known to the author:—

Operator.	Sex.	Age.	Duration of Disease.	Duration of Relief.	Final Results.	Reference.
Carnochan . . .	M.	69	5 years	14 months	Cure	<i>Amer. Jour. Med. Sci.</i> , 1858, p. 134.
Carnochan . . .	M.	54	29 "	7 weeks	Cure	Ditto.
Carnochan . . .	F.	55	6 "	1 month	Cure	Ditto.
Nussbaum, . . .	F.	38	9 "	—	Cure	<i>Aertztliches Intelligenz Blatt</i> , 1863.
Blackman . . .	F.	35	14 "	20 months	Temporary relief, then relapse	<i>Amer. Jour. Med. Sci.</i> , 1869, 1870.
Wood, J. R. . . .	M.	—	5 "	6 "	Improvement	<i>New York Med. Jour.</i> , 1879.
Wood	M.	42	several years	2 years	Cure	Ditto.
Thorndike . . .	M.	61	31 years	1 month	Cure	<i>Boston Hosp. Reps.</i> , 1877.
Wood, J. R. . . .	M.	50	10 "	2 years	Cure	<i>New York Med. Jour.</i> , 1879.
Cheever	F.	65	18 "	2 "	Great relief and partial relapse	<i>Boston Hosp. Reps.</i> , 1877.
Dumont	M.	48	2 months	9 "	Cure	<i>Deut. Zeit. für Chir.</i> , 1883.
Fowler	M.	53	18 "	1 "	Cure	<i>Proc. Med. Soc. of King's County</i> , 1877, p. 176.
Chavasse	M.	50	14 years	—	Cure	<i>Med. Chr. Trans.</i> , vol. lxvii. 1884.
Brok	M.	67	6 "	—	Complete cure	<i>Mich. Med. News</i> , vol. iv. No. 1.
Wier	M.	47	2 "	9 months	Complete cure	<i>Med. Gaz.</i> , New York, 1881.
Davis	M.	43	6 "	9 "	Complete cure	<i>Chicago Med. News</i> , vol. iv.
Wallace	M.	34	9 "	—	Improved	<i>Pittsburgh Med. Jour.</i> , 1882.
Gerster	F.	42	2 "	1 year	Improved	<i>New York Med. Jour.</i> , Jan. 1884.
Lange	M.	40	"long time"	2 years	Cure	Ditto.
Gerster	M.	63	2 $\frac{3}{4}$ years	2 "	Cure	Ditto.
Howe	F.	45	12 "	1 "	Cure	<i>Phil. Med. News</i> , 1884.
Gerster	M.	38	—	6 months	Improved	<i>New York Med. Jour.</i> , Jan. 1884.
Fowler	M.	53	3 months	1 $\frac{3}{4}$ years	Cure	<i>New York Med. Rec.</i> , vol. xxvi.
Rockwell	F.	16	—	—	Cure	<i>Annals of Surgery</i> , April 1885.
Fowler	M.	45	3 years	—	Cure	<i>Rec. St. Mary's Hosp.</i> , Brooklyn, 1885.
Fowler	M.	38	20 "	—	Death from tetanus	Ditto.

Dr. Fowler thus summarizes the twenty-six cases recorded in his tables:

I. Number of cases in which relief continued for three years or longer, 3.

2. Number of cases in which relief continued for two years, but less than three years, 6.

3. Number of cases in which relief continued for one year, but less than two years, 9.

4. Number of cases in which relief continued for six months, but less than a year, 3.

5. Number of cases in which relief lasted less than six months, 5.

6. Average duration of relief: one year, five months, sixteen days.

To these may be added the following eleven, which may be thus similarly summarized:

1. Number of cases in which relief continued for three years or longer, 2.

2. Number of cases in which relief continued for two years, 1.

3. Number of cases in which relief continued for one year, 2.

4. Number of cases in which relief continued for six months, but less than a year, 1.

5. Number of cases in which relief lasted less than six months, 3.

Operator.	Sex.	Age.	Duration of Disease.	Duration of Relief.	Final Result.	Reference.
Vanderveer .	F.	40	3 years	8 years	Cure	<i>Trans. American Surgical Assoc.</i> , 1881 to 1883, vol. i.
Vanderveer .	F.	37	6 "	3 months	Cure, after another operation on inf. dental	Ditto.
Vanderveer .	M.	68	14 "	2 years	Cure	Ditto.
Wagner .	F.	35	14 months	20 months	Cure	<i>New York Med Jour.</i> , 1879.
Wagner .	F.	45	2 years	3 "	Relief, then relapse	Ditto.
Dennis .	M.	42	several years	2 years	Cure	Ditto.
Mussey .	M.	32	5 "	—	Cure, after operation on inf. dental also	Ditto.
Podrazki .	M.	36	—	1 month	Cure	Ditto.
Danson .	M.	22	—	8 years	Cure	See Vanderveer, <i>supra</i> .
Danson .	M.	—	—	—	Relief, after operation on inf. dental also	Ditto.
Clutton .	M.	51	9 years	15 months	Complete relief, then slight relapse	<i>St. Thomas's Hosp. Reps.</i> , 1885, p. 218.
Clutton .	M.	66	9 "	8 "	Relief, then slight relapse	Ditto.

The following are brief notes of a few of the cases alluded to in the above tables. They give some idea of the severity of the symptoms for which the operation was undertaken, and of the difficulty experienced in the treatment of the disease in question :

Vanderveer.—Excision of Meckel's Ganglion for Neuralgia.—Cure.*

Miss B., aged forty, had suffered for three years from neuralgia of the right side of the face. She had previously enjoyed good health. All the teeth had been removed from the right upper jaw and some from the right lower jaw. "The pain would start in the upper jaw, extend over the face, pass down, around, and through the lower jaw to the chin, and along the right side of the tongue, also penetrate the temporal region, leaving a sensation of heat in the mouth so severe that at times she would be unable to take a drink without having the pain aggravated for hours." On Sept. 5, 1875, excision of Meckel's ganglion. Sharp hæmorrhage from back of wound. The result was a perfect cure as late as 1883.

Vanderveer.—Excision of Meckel's Ganglion for Neuralgia.—Cure.

Mr. H., aged sixty-eight, said that thirty years ago he received a blow on the left malar bone, and that for fourteen years past "he has noticed a dull heavy sensation in the forehead on the left side, and this was followed in a short time by sharp darting pains under the eye which could be started by touching the part. The pain would begin with a jerk, sometimes at the nose and at other times at the eye." Medicine was no good. On March 20, 1882, excision of Meckel's ganglion was performed. The wound healed in six days, and from that time onward he had no pain.

Dennis.†—Removal of Meckel's Ganglion for Neuralgia.—Cure.

The patient was a man, aged forty-two, and came under notice on March 20, 1866. He had suffered for several years with facial neuralgia, the right superior maxillary nerve and its branches being the parts most affected. He had been treated medicinally, and the infra-orbital nerve had repeatedly been subcutaneously divided with but slight relief. He had always led a sedentary life. On April 2, 1866, Meckel's ganglion was removed by means of incision in the cheek, and trephining the antrum with a half-

* *Trans. Amer. Surg. Association*, 1881-3, vol. i.

† *New York Medical Journal*, 1879, vol. xxix. p. 576.

inch trephine. The next day the patient was quite free from pain. On the sixth day the wound had entirely healed, with the exception of the inferior angle, which had been kept open for drainage. For two years after the operation he suffered no pain whatever, and was then lost sight of.

Mussey.—Removal of Meckel's Ganglion and Excision of the Inferior Dental Nerve.—Success.*

The patient was a man, aged thirty-two, who after exposure to intense cold began to suffer from neuralgia, confined chiefly to the superior maxillary nerve. For five years the patient resorted to all kinds of medical treatment without relief. Meckel's ganglion and the superior maxillary nerve were then removed, with the result that pain left the cheek, but in the course of the following two months was felt along the inferior dental nerve, and became so severe that an operation for the removal of that nerve was performed. In the opinion of the patient the operation was a complete success.

Podrazki.†—Excision of Meckel's Ganglion.—Cure.

The patient was a man, aged thirty-six, who had suffered from severe neuralgia. The superior maxillary nerve was removed at the foramen rotundum according to Carnochan's method. The nerve after removal was found to be remarkably thick and deeply congested. The pain left the region of the cheek after the operation, but in a day or so reappeared in the supra-trochlear nerve. Eleven days after the first operation resection of the frontal nerve was performed just before it divides into the supra-orbital and supra-trochlear branches. Fourteen days later the patient was free from pain and left the hospital, and since then nothing has been recorded concerning him.

Chavasse.‡—Removal of Meckel's Ganglion.—Neurectomy of the Second Division of the Fifth Nerve.—Cure.

The patient, a man aged fifty, came to the Birmingham General Hospital, on July 19, 1882, with the history that fourteen years

* *New York Medical Journal*, 1879, vol. xxix. p. 576; *Cincinnati Lancet and Observer*, Aug. 1869, p. 449.

† *New York Medical Journal*, 1879, vol. xxix. p. 576; *Vienna Med. Woch.*, No. 103, 1869, p. 1710.

‡ *Medico-Chirurgical Transactions*, vol. lxii. p. 145.

previously, after a heavy drinking bout, he suddenly felt pain in the upper molar teeth of the right side. There were no decayed teeth, but as the pain persisted in the last upper two molars these were removed, but without relief. After their removal paroxysms of pain frequently recurred, and of late years had lasted longer. Sometimes the spasms were only felt five or six times daily; at others they followed in quick succession. The pain was always worse in wet weather, and was increased by any movement of the jaws. Medical treatment of all kinds had been tried without success. When he came under notice it was found that the first feelings of the painful paroxysms were referable to the periphery of the posterior dental branches of the second division of the fifth nerve on the right side, at the point where the molar teeth had been removed. The pain then seemed to go up the temporal fossa, and was felt there and in the lower eyelid, at the side of the nose and in the upper lip. This course was nearly always followed during an attack. The right eye watered, the tears streaming over the face. On Oct. 3rd an operation was performed after Carnochan's method, and Meckel's ganglion was removed. There was considerable hæmorrhage when the posterior wall of the antrum was perforated. By Oct. 16th the wound had healed. On testing sensation the patient stated that the most numbed parts of the face were the right side of the upper lip, and the structures lying over the lower wall of the orbit on the affected side. Along the side of the nose and on the cheek sensation was impaired, but an examination of the soft palate showed no evidence of any loss of sensation. A month later the sensation in the face was gradually returning. In Feb. 1884, there had been no return of the pain.

Chavasse (Case 2).—Removal of Meckel's Ganglion for Epileptiform Neuralgia.—Cure.*

The patient was a man, aged forty-six, who eleven years previously, while at work in a warehouse, experienced severe pain in the upper molar teeth of the left side. This was followed by a copious flow of tears from the eye on the same side. The painful spasm was subsequently repeated. At first it was momentary, and only felt at intervals of some hours, but it soon recurred more frequently, and would be repeated five or six times in an hour. The intensity of the pain was often so great that it would waken him

* *Medico-Chirurgical Transactions*, vol. lxvii. p. 145.

from sleep. It could be elicited by speaking, masticating, walking rapidly, and always by washing the face with cold water. The removal of the upper molar teeth seemed to give relief for a short time, but the patient gradually lost flesh, appetite, and sleep. All medicinal treatment was useless. On admission to the Birmingham Hospital the patient was found to be pallid and emaciated. He was unable to eat solid food owing to the pain induced by the movement of the jaws. To walk across the ward or to talk produced paroxysms. Continuous pressure on the site of the upper molar teeth would induce the same. The pain was referred to the left temporal fossa, to the eye, and the side of the nose. During an attack there was no manifest injection of the ocular vessels. On Feb. 9, 1883, the infra-orbital nerve with Meckel's ganglion was excised. There was again considerable hæmorrhage after removing the posterior wall of the antrum. By Feb. 26th he was able to eat solid food without inconvenience. He walked about, talked, slept, and felt no pain. On March 5th on testing sensation it was found that on the affected side there was a diminution of sensibility along the side of the nose, the lower eyelid, and the left portion of the upper lip. In the soft palate no abnormal condition could be detected. On July 1, 1884, he still remained well, and had no return of the pain.

Wood.—Epileptiform Neuralgia.—Removal of Meckel's Ganglion.
Relief.*

The patient, a woman, had suffered from severe facial neuralgia for a long period. Subcutaneous operations upon the different facial nerves had been performed to no purpose. On Sept. 29, 1869, Meckel's ganglion was excised. For four months she had no return of pain. Nine months after operation she returned to state that new pains had come in the lower jaw, and these on examination were found to be in the course of the inferior maxillary nerve. A portion of this nerve was therefore removed, after trephining the lower jaw. For many months after this second operation the patient remained perfectly well.

Wood.†—Removal of Meckel's Ganglion.—Failure.

The patient noticed pain five years previous to his admission into the Bellevue Hospital, on Jan. 13, 1870. The pain was in

* *New York Medical Journal*, 1879, vol. xxix. p. 576.

† *Ibid.*

the region of the upper lip, and extended towards the left eye. It continued for about two years, and then spontaneously ceased. He could assign no cause, however, other than that of sleeping on damp ground. After an intermission of six months the pain returned more severely than at first. On admission, the attack from which he was suffering had continued for very nearly two years in spite of various treatment. On Jan. 29, 1870, Meckel's ganglion was removed. The wound healed well, and the patient was free from pain for about seven months. Pains of a neuralgic character then appeared in the track of the inferior maxillary nerve. To relieve this the inferior maxilla was trephined and the dental nerve divided. In June 1875, the patient returned to hospital, professing to suffer from his old complaint. He had, however, become a confirmed opium-eater, and his statements were inaccurate. Without apparent cause multiple abscesses formed in different parts of the body, and he died on Nov. 30, 1877. Post-mortem examination showed no trace of the nerve beyond the foramen rotundum, which was closed on its interior surface by bone. The intra-cranial portion of the nerve was well preserved, although there appeared to be a larger number of small nerve-fibres in the nerve on the side operated on than on the other.

I think that a study of the tables and of the clinical histories of the patients on whom the operation of excision of Meckel's ganglion has been performed, bears out the proposition I have already made, that the operation is a justifiable one, and, further, that it holds out some real hope of relief or of cure; though I am certainly of opinion that in England, at any rate, the number of cases in which it can be required is really very small.

Ligature of the Common Carotid for Facial Neuralgia.—I have had no personal experience of the efficacy of this operation, and am therefore dependent upon the reports of others.

Wyeth* has collected sixteen cases, of which one died, eight were cured, two were not at all improved, and six had some relief varying from two to four and eight years.

Fowler† summarizes eighteen cases, some of which are the same as those recorded by Wyeth, and concludes as follows:

“Number of cases in which duration of relief exceeded three years, four; number of cases in which relief lasted between one

* *Surgical Essays*, New York, 1879.

† *Loc. cit.*

and three years, three; number of cases in which duration of relief was less than one year, four; number of cases in which only partial relief followed operation, two; number of cases in which death was attributed to operation, one; number of cases reported cured, but in which duration of relief could not be ascertained, two. Longest period of relief, eleven years; shortest period of relief, two months."

It is probable, I think, that such results as these are more satisfactory than would be the case if all the operations performed were recorded; and I do not think that such a low mortality could be expected as one in eighteen, seeing how frequently death results from failure of blood-supply to the brain after ligature of the common carotid. The operation in question is indeed one which from its severity should not be undertaken except as a last resort, and not, in my opinion, until after the ligature of the external carotid alone, as recommended by Fowler and Roser,* has been tried. Roser indeed reports one cure after this latter operation.

The following instances indicate at least the intractability of some cases of neuralgia, and the circumstances under which surgeons have been induced to practise ligature of the common carotid:

Ferdinand Gross.† — Facial Neuralgia. — Ligature of Carotid. Neurectomy of the Inferior Dental and Infra-orbital Nerves.

"J. G., a German, aged sixty-four, married, by occupation a piano polisher, applied to me Aug. 29, 1873, suffering from neuralgia of the right side of the lower jaw. At that time he was in his fifty-fifth year and had always enjoyed good health. His family history was good. Under treatment by morphia and removal of decayed teeth he rapidly improved and remained free from the disease for three years and three months, the second attack occurring in Dec. 1876, and lasting for three months. In June 1880 he again had an attack of neuralgia, chiefly in the lower jaw, in the mouth and lips. At this time almost all the remaining teeth were extracted without improvement—if anything the pain was rather increased by the removal of the teeth. The acts of mastication and deglutition induced such paroxysms of suffering that he would only at long intervals venture to take a little nourishment in a liquid

* *Archiv für Klin. Chir.*, Band xvii.

† *American Journal of Medical Sciences*, vol. lxxxv. p. 366.

form. The vaso-motor and trophic disturbances above mentioned were congestion of the conjunctiva, increased lachrymation, blushing of the right cheek accompanied with lachrymation, and a glossy appearance of the skin. Herpetic eruptions upon the lips and cheeks were sometimes seen ; a yellowish fur upon the tongue was thicker and more tenacious upon the affected side. The buccal mucous membrane was swollen, and saliva would flow from the mouth. During this third attack injection of morphia and atropia were employed without material benefit, as well as other therapeutic remedies. Whilst reflecting what might be the best means the art of surgery had to offer for the relief of this sufferer, I found that compression of the right common carotid artery relieved the pain in less than half a minute in the entire affected districts, save at one spot on the lower jaw, and here, too, it was rendered less intense. Having explained to him the nature of the operation, I advised him to submit to a ligature of the right common carotid artery, and on Aug. 19, 1880, I ligatured the artery with carbolized silk. Twenty-four hours after the operation the patient began to complain of headache ; it was not confined to one side, but entirely disappeared after the ninth day. On the seventh day there was a slight transient defect in his voice of a purely functionary nature. As to the neuralgia, the immediate effect of the operation was complete relief of the entire districts supplied by the first and second divisions of the fifth nerve, and modification in the domain of the third division. The pain was left only at one spot on the lower jaw. The day after leaving the hospital the patient had an attack of inflammation of the lungs, from which he recovered slowly. The neuralgia in the lower jaw returned, and by Oct. 6th was severe. By Oct. 20th he suffered so much that he could not utter a word, and all his answers were made in writing. The pain did not extend beyond the lower jaw. Electricity was now tried, as well as various medicines, and gave the patient some temporary relief. In the early part of April 1881 he was re-admitted to the hospital, where, as his suffering was still intense, I performed neurotomy upon the inferior dental nerve on April 19th, the nerve being exposed after trephining the lower jaw. The inferior dental artery was severed at the same time, but the bleeding was insignificant. On the same evening the patient complained of deafness in the right ear, but all pain about the jaw was gone. The patient remained free from neuralgia after this for about one year and three months, but in the latter part

of Aug. 1882, neuralgia recurred for the first time since the ligature of the carotid, in the upper part of the cheek, the infra-orbital region, and on the side of the nose, and, quickly following this, it returned in the lower jaw. On Sept. 14th the infra-orbital nerve was exposed, and the whole of it removed as far back as the spheno-maxillary fissure. On the second day after the operation the patient experienced a little pain in the lower jaw. In the district supplied by the superior maxillary nerve the neuralgia was all gone, and there was anæsthesia of the cheek and side of the nose. He returned home in a week with the wound almost healed. For four weeks everything went well, but then pain returned in the region of the lower jaw, where neurotomy had been performed eighteen months before. On Nov. 11th the lower jaw was trephined in two places. An incision was made in the line of the old scar just above the angle of the jaw, and the trephining so applied as to include a portion of the bone just above where it had been trephined before. A piece of the nerve was found sticking in the cancellous structure of the disc of the removed bone, having been divided in the act of trephining. It was plain therefore that the nerve had become regenerated and re-united. Next an incision was made along the edge of the jaw, and the bone trephined a little to the outer side of the mental foramen. The nerve was then seized and easily withdrawn in its entire length."

Hutchinson, Joseph.—Ligature of the Common Carotid for Persistent Neuralgia.*

The author records two cases. In the first, temporary improvement had previously followed removal of the alveolar margin of the jaw and resection of the inferior dental nerve. Ligature of the carotid caused cessation of pain for three and a half years. It then returned, though in a greatly diminished degree.

In the second case, numerous operations for resection of nerves had previously been undertaken, but with little success. Ligature of the common carotid was of no avail.

Nussbaum.†—Resection of the Infra-orbital after Ligature of the Carotid for Neuralgia.—Cure.

A woman, aged thirty-eight, suffered from traumatic neuralgia of the face. She had undergone numerous operations before she

* *Rev. des Sci. Méd.*, Oct. 1885.

† *New York Medical Journal*, 1879, vol. xxix. p. 576.

came under Nussbaum's treatment. Various operations were performed for her relief. Amongst others, the common carotid was tied and the ascending ramus of the lower jaw trephined and the inferior dental nerve resected. Five months later the neuralgia returned, and then the infra-orbital nerve was removed nearly to the foramen rotundum. For several months after this operation there was no return of neuralgia.

Billroth.—Neuralgia of the Fifth Nerve treated by Neurectomy and other operations, including Ligature of the Carotid.*

The patient was a man, aged sixty, who two years previously had first experienced pain in the left cheek and teeth. The attacks became more frequent, occurring at first every week, then every second day, and finally daily for four months before he came under notice. The paroxysms came on several times daily, being brought on by the slightest movement of the muscles of the face. Numerous teeth had been extracted, and a great amount of medicine had been taken without benefit. In April 1864, three-fourths of an inch of the infra-orbital nerve was excised. For a few days after this operation the patient remained free from pain. The old trouble then recommenced, though the attacks were less frequent and less severe. On further examination it was considered that the affection was in the course of the second division of the fifth nerve, and that the pain was always reflex, and originated in peripheral excitation. On May 12, 1864, the alveolar portion of the upper jaw was removed, with the result that the attacks ceased, and for three-quarters of a year he continued perfectly well. Then at long intervals slight symptoms recurred, but in the autumn of 1865 the attacks began to increase in frequency and severity; and in 1866 his condition became so intolerable that he was unable to continue his work any longer. In Feb. 1866 osteo-plastic resection of the superior maxilla was performed. The posterior wall of the antrum and back part of the floor of the orbit were broken away. Then the second division of the fifth nerve was traced, and the trunk of the nerve and the orbital and dental branches were cut off close to the foramen rotundum. After this the attacks of pain ceased. On examination the entire trunk of the nerve was found to have been removed, but Meckel's ganglion was left. Microscopically, the nerves appeared natural. In March

* *Clinical Surgery*, p. 58.

the neuralgic symptoms returned again, and soon the attacks became more frequent. The buccinator nerve was then divided in April. In May neuralgic pains appeared about the upper jaw and in the neighbourhood of the chin. An incision was then made from the mouth towards the lateral wall of the antrum so as to divide if possible the posterior dental nerve. The mental nerve was also divided. In Jan. 1867 there was more pain, and in July the patient again came desiring a further operation. The left common carotid artery was therefore tied. A few days after the operation the patient had slight attacks of pain, which was then diminished and entirely ceased at the end of the first week after the operation. The pain again recurred, and the patient died after having taken large doses of morphia for several months.

If, then, any operation is undertaken for the cure of facial neuralgia, and especially if the neuralgia is of the epileptiform type, it is evident that we have the choice of several operations. The cases I have detailed support, I think, the opinions expressed at the commencement of the chapter—namely, that nerve-stretching should first be tried; and they also show very clearly that in not a few cases more nerves than one must be stretched. Another point is worthy of some attention—namely, that relief does not always immediately follow operation, although it may ultimately ensue, so that before further operations are undertaken a sufficient time should be allowed to elapse in order that the effects may be properly appreciated. I have very recently seen an excellent example of this in a patient in whom the infra-orbital, the inferior dental, and the auriculo-temporal nerves were stretched without much immediate relief, although in the course of six weeks all pain gradually, and apparently finally, passed away, and the patient is now in excellent health, whereas formerly her life was rendered miserable by constant neuralgia.

And supposing that although many nerves have been stretched, months have elapsed without relief, what should be the next step? I think myself that the stretching should be repeated before other operations are undertaken, and if anything else is subsequently done it should rather be excision of a considerable length of the affected nerve than mere neurotomy, which, I think, is not so efficacious as stretching.

As to the excision of Meckel's ganglion, it certainly does appear to give relief when other means have failed, and the operation,

although troublesome, is by no means so difficult as might be anticipated. Ligature of the carotids should certainly not be undertaken until after a thorough trial of operations on the nerve-trunks.

The Teeth and Gums in Facial Neuralgia.—I do not wish to say more than a very few words on this subject. In the treatment of a disease in which peripheral irritation of any kind is to be avoided, it is of course necessary to see to the state of the teeth, and, where the latter are carious, efficient treatment should be pursued.

But, on the other hand, I feel sure that the removal of teeth which are simply painful is not only unwise, but is also likely to result in serious additional trouble to the patient. I have certainly seen cases in which, after removal of healthy teeth, the gums have been left in an infinitely more tender condition than they were previous to the extraction, and would never advise the removal of a tooth merely on account of pain referred to it.

The condition of the gums, in addition, merits attention, for, in some few cases, neuralgia has been cured by excising portions of gum which were unduly sensitive to pressure.

Thus, cases are recorded by Gross (in his *Surgery*) in which excision of the alveolar borders of the inferior maxillæ has resulted in a cure of neuralgic pain. Duplay* details a similar case where a neuralgia of eight years' duration was at once cured by resection of the alveolar margin at the place where the first molar tooth had been drawn, and which was very sensitive, and Morris, in the discussion at the Medico-Chirurgical Society on Mr. Chavasse's cases of excision of Meckel's ganglion, narrated a case in which he had cured a neuralgia, which had not yielded to nerve-stretching or neurotomy, by removing portions of the gums on which were small papillary growths of exquisite tenderness.

In all cases, therefore, where there is any reason to suspect that the neuralgia may be dependent on some abnormal condition of the gums, a local operation should be undertaken before either nerve-stretching or neurotomy.

* *Rev. des Sci. Méd* Oct. 1885.

CHAPTER XXV.

NON-TRAUMATIC NEURITIS.

ALTHOUGH the subject of non-traumatic neuritis is one which has hitherto been dealt with rather from a medical than from a surgical standpoint, I have felt that in a work on the Injuries and Diseases of Nerves it would be impossible to pass over the subject without being guilty of a serious omission.

The boundary-line between medicine and surgery is nowhere strongly marked, and in the present case it is less plain than usual. Considering, however, that local diseases of peripheral parts and of peripheral origin are usually conceded to be within the domain of surgery, I think that many cases of non-traumatic neuritis may fairly be brought within the scope of my present work. And, indeed, they well may be, for the symptoms to which neuritis not infrequently gives rise are of such a nature as to bring the patient into the surgical wards of a hospital rather than into the medical ones, and to lead him to consult the surgeon rather than the physician.

I do not, however, propose to deal with those forms of neuritis which are of toxic origin—*e.g.*, lead palsy, arsenical neuritis, &c.—nor with those which occur in connection with tuberculosis and the various zymotic diseases, and which may perhaps explain the nervous symptoms met with in some cases of diphtheria and typhoid fever; and, before proceeding further, I wish to define more clearly the meaning of “neuritis.”

The term neuritis is frequently both misleading and incorrect. By it is undoubtedly implied an inflammation of the nerve, and although in some cases this is present, in a large number of other instances no inflammatory changes of any sort or kind are found.

In those cases to which the term is correctly applied, the changes that are found are precisely similar to those met with in the instances of traumatic neuritis already described in an earlier

chapter, and include increased vascularity, cell exudation, and formation of fibrous tissue, with increase in size of the nerve-trunk.

In other cases to which the term neuritis is wrongly applied, the changes met with are precisely those which follow on nerve-section, and have already been detailed under the name of Wallerian degeneration.

In such there is no sign of inflammation, but merely a degeneration and disintegration of the nerve-tubules, though not always proceeding to so great a destruction as after nerve-section. To cases such as these I should personally much prefer to apply the term "degeneration," prefixing to it an adjective indicating the cause—*e.g.*, "syphilitic degeneration of nerves," "alcoholic degeneration," &c. ; and in cases where no definite cause could be assigned, the term "idiopathic" might be used until further study of such obscure cases supplied a better.

The term "neuritis" has, however, been so largely employed that for the present I shall not venture to supplant it, and shall therefore continue to use it with the double meaning which it has hitherto borne.

Non-traumatic neuritis may be either local or multiple ; it may affect one nerve-trunk alone, or the several nerve-trunks and their branches in one limb, or may extend to any or all of the nerves in the body. Cases such as the latter are known by the name of "multiple neuritis," and may occur either idiopathically or as the result of alcoholism, syphilis, and of other causes acting through the constitution.

The *local* symptoms of neuritis vary in different cases. Frequently all the functions of the nerve or nerves are interfered with, but in many instances the stress of the disease falls upon either the sensory, motor, or trophic functions more particularly, attacking one whilst leaving the others comparatively intact. With regard to sensation, the first symptoms are referred to the periphery, and consist of numbing, pricking, and tingling sensations, often accompanied by hyperæsthesia, and followed after some time by anæsthesia. In connection with the motor fibres there are noticed in many cases muscular tremors and twitchings, quickly followed by loss of power, amounting to complete paralysis, and often accompanied by muscular wasting. Sometimes there is no alteration in the electrical reactions, but in many instances there is diminution or loss of faradic contractility, and more rarely the

reaction of degeneration when tested by the galvanic current. Various trophic lesions may be present, such as I have already described as the sequel of nerve injury. Of these the most common are glossy skin, eczema, pemphigoid eruptions, and ulcers.

In cases where genuine inflammation is present, the symptoms are precisely similar to those described as occurring in traumatic neuritis, and include swelling of the nerve with pain and tenderness in its course. The severity of the pain and tenderness will vary with the acuteness of the case.

In the three following instances no cause for the neuritis could be detected. In two cases the motor functions were most affected. In the other, both the sensory and trophic functions were much interfered with, whilst the muscles were not materially implicated.

Paralysis of the Extensor Muscles of the Thumb.

James C., aged forty-seven, was admitted into St. Bartholomew's Hospital on Dec. 13, 1883. No history of syphilis or of lead poisoning could be elicited. Eleven weeks ago he fell and hurt his arm. A week later splints were applied and kept on for three weeks. Fourteen days after the splints were removed and whilst he was at his work the thumb suddenly dropped powerless towards the hand, and has since remained so. Present condition: No power over the extensors of the thumb, which is flexed towards the palm. All other muscles normal. Sensation and nutrition normal. Very slight reaction to faradism of the extensors of the thumb. No reaction of degeneration. To be galvanized twice a week.

Jan. 17, 1884.—No improvement, but a slight area of hyperæsthesia over the lower part of the radius.

Oct. 7th.—The extensor ossis metacarpi pollicis acts to faradism. No other change except that the hyperæsthesia has passed off.

July 20, 1885.—No change. Extensors still quite paralysed.

Sept. 1886.—No further change.

Idiopathic Paralysis of the Extensor Muscles of both Hands.

D. S., aged thirty-three, came to St. Bartholomew's Hospital on Dec. 10, 1883. He was a bootmaker. He says that three years ago, while at work, the *right* hand suddenly became numb. A week later the hand and arm were red and swollen on their dorsal

surface. This condition lasted fourteen days, and then got better. After this the hand became liable to get suddenly numb after he had been at work some time. It then got quite well again. Just a year after the first attack the hand again became suddenly numb while he was lifting a jug. From this time it never recovered, but remained permanently weak. The last month he has noticed wasting of the interossei muscles of the *left* hand. He says this hand suddenly dropped while at work ten weeks ago, and has remained dropped ever since. Present condition: Double wrist-drop with paralysis of the extensors and supinators. The right supinator longus reacts to faradism, but no other muscle supplied below the elbow by the musculo-spiral reacts at all. On the left side all the extensor muscles react very feebly to faradism. He has very slight power over the extensor muscles of both hands. Reaction of degeneration is marked in the right arm; in the left arm A.C.C. = K.C.C.

July 12, 1885.—He is worse. None of the extensors, except the extensor ossis metacarpi pollicis of the left side, react to faradism.

Sept. 19th.—He complains of recent spasmodic contractions of the flexor muscles of the forearm. He cannot use the arm much. His only occupation is that of a doorkeeper. Electrical examination—Galvanism: Left arm; decreased irritability. Reaction normal in quantity in the muscles supplied by the musculo-spiral and ulnar nerve. Those supplied by the median in the forearm show the reaction of degeneration, A.C.C. > K.C.C. Right arm: Ulnar muscles normal. Reaction normal in quantity of muscles supplied by the median nerve in the forearm, but neither the long flexors of the index or of the thumb act at all, and after contraction of the two long flexors of the middle and ring fingers and palmaris longus, caused by the anodal closure, there ensues an automatic, spasmodic, fibrillar contraction of the same muscles. There is no reaction of the muscles of the ball of the thumb supplied by the median nerve. To the interrupted current—Right arm: Loss of faradic contractility in all the extensor muscles, but the supinator longus acts. The ulnar muscles react normally. Neither the muscles of the thumb nor the long flexor of the thumb react. Left arm: No reaction of the extensor muscles, with the exception of those of the thumb. There is partial loss of faradic contractility in the muscles supplied by the median nerve, very marked in the muscles of the thumb. Ulnar muscles normal.

Anæsthesia and partial Gangrene of the Fingers of each Hand.

G. F., aged twenty-nine, was admitted into St. Bartholomew's Hospital on Jan. 14, 1885. On the 11th he noticed pain in the ring and little fingers of the right hand and on the inner side of the left hand. On the 12th he lost feeling in these places, and also slightly in the index and middle fingers of the right hand and the second and third toes of each foot. The ring finger of the right hand began to get black on the 11th; the little finger also changed colour on the 14th. On admission, he was found to be a half-starved man, out of work, but with no definite disease. His previous history was fairly good, as was also his family history. His hands presented the following appearance: On the radial side of the proximal phalanx of the right ring finger was a small black spot, the rest of the finger being of a blue-black colour; this colour extended some distance up the dorsum of the hand and little finger. On the inside of the left hand was a similar black spot, surrounded by the same blue-black colour. There was general numbness of the fingers and hand. The second and third toes of the left foot were of a dusky black colour, but this was not so marked as on the hand.

17th.—The two hands have been enveloped in cotton-wool: the discoloration has disappeared, except that the two black spots remain, and there is a bulla filled with blood over that on the inner side of the left palm. Sensation: Entirely lost over the ulnar distribution, and so much impaired over all the rest of the hand, that although he can feel a pencil-point he cannot localize it. Muscles: All the interosseous muscles of the hands are very feeble. The hands are not now cold. Electrical examination: No alteration in the reaction of the muscles. Under treatment by quinine and a liberal diet the patient improved, though very slowly. Small sloughs formed at the black patches, and sensation was not perfect until three weeks after admission.

I think there can be no doubt that in all these cases the diagnosis of "neuritis" was justified by the symptoms and by the behaviour of the muscles in the first two to faradism and galvanism. The extreme suddenness with which the muscular paralysis appeared is most striking.

In reading the various recorded cases of non-traumatic neuritis, the conclusion appears probable that some nerves are more prone

to be affected than are others. And, speaking of cases in which there is no cause apparent, the muscles of the arm appear to be more frequently paralysed than those of the leg.

Attention has been drawn by various Continental authors, and particularly by Erb, to a paralysis of the muscles which derive their nerve-supply from the fifth and sixth cervical nerves. Nine such cases have at any rate been recorded; and although in some of them an injury appeared to have been the exciting cause, in the others nothing could be found to account for the paralysis.

The following cases will serve as an example of this class of paralysis, for in all the patients there was a great similarity in the symptoms:

Erb.—Paralysis of the Fifth and Sixth Cervical Nerves.
Marked Reaction of Degeneration.*

A man, aged fifty-two, after carrying a heavy load upon his head noticed pain in the arm, shoulder, and left side of the neck, with numbness of the thumb and index finger, and great weakness of the arm. Five weeks later he was admitted into the hospital, when he was found to have complete paralysis of the left deltoid, biceps, coraco-brachialis, and supinator longus. The short supinator was also very feeble. All the other muscles were normal. In the thumb and index finger there was a sense of numbness and slight loss of sensation. Electrically examined, there was complete reaction of degeneration in the paralysed muscles, which were also atrophied. Seven weeks of treatment by galvanism sufficed to cure the patient.

Erb.†—Paralysis of the Fifth and Sixth Cervical Nerves.

A young man, aged seventeen, had noticed for two months before coming under treatment numbness of the thumb and index finger on the left side. Fifteen days later paralysis of the arm supervened. There was no apparent cause. On examination there was found to be paralysis of the deltoid, biceps, coraco-brachialis, and supinator longus. Later on there was slight paralysis of the supinator brevis and of the muscles innervated by the median nerve. There was complete reaction of degenera-

* *Centralblatt für Med. Wiss.*, 1876, p. 396; *Gazette Hebdomadaire de Médecine et de Chir.*, 1880, p. 246.

† *Ibid.*

tion and slight atrophy of the muscles. The patient was cured after four months' treatment by galvanism.

Remak.—Paralysis of the Fifth and Sixth Cervical Nerves.*

The patient was a woman, aged forty-eight, in whom (without apparent cause) a paralysis of the right arm developed. The muscles paralysed were the deltoid, biceps, coraco-brachialis, and supinator brevis. They were all atrophied, and, electrically examined, showed marked reaction of degeneration. On examining this patient, by placing an electrode on the level of the sixth cervical vertebra and stimulating the muscles of the sound arm, there was found to be strong contraction of the deltoid, biceps, and coraco-brachialis. A similar examination of the affected side showed no reaction whatever of the same muscles.

Why the fifth and sixth nerves should thus be selected I cannot say. The diagnosis appears to be sufficiently easy, except that it is difficult, or perhaps impossible, to entirely eliminate some disease of the large ganglion cells in the anterior horns. I think this is rendered improbable by the presence of pain and of some loss of sensation, for no disease of the anterior horns could account for such symptoms, although in all the cases they were not noticed. The complete recovery of most of the patients is again in favour of an affection of the nerve itself and not of the spinal cord, whilst the reactions to electricity satisfactorily eliminate any cerebral disease.

Although, however, the fifth and sixth nerves seem to be especially picked out by this form of neuritis, the other nerves of the upper extremity do not always escape, as the following cases will show :

Straus.†—A Case of Spontaneous Paralysis of the Brachial Plexus with integrity of the Median Nerve.—Rapid Cure under Faradism.

A man, aged thirty-three, a clerk, came into the hospital on June 6, 1879. He was a strong and vigorous man, but was absolutely incapable of moving the right upper arm. His history was that four days before admission when he woke in the morning he

* *Gazette Hebdomadaire de Médecine et de Chir.*, 1880, p. 248; *Société de Médecine de Berlin*, 1877.

† *Gazette Hebdomadaire de Médecine et de Chir.*, 1880, p. 244.

found that the right hand was tingling and numb; at the same time his forearm and arm appeared heavy. The patient had not been exposed to any cold; had not slept on anything hard; he had no fever; no pain; no other illness. There was, in fact, no cause for the paralysis. On the next day, and the day following that again, the tingling and numbness extended up the arm, which became gradually paralysed, and at the end of two days he was unable to flex the forearm upon the arm. Upon examination he was found to have complete immobility of the right arm, which was red and slightly œdematous. The swelling and redness were so pronounced that he was thought by some of the pupils to have articular rheumatism. Besides numbness the patient complained of a sensation of cold, and to the touch the arm felt distinctly colder than normal. An examination of the muscles showed that there was complete paralysis of all those supplied by the brachial plexus except the muscles innervated by the median nerve. Sensation was lost over an area corresponding to that which was paralysed. An electrical examination showed that the faradic and galvanic contractility of the muscles was normal. There was nothing abnormal in the axilla. The patient was treated by faradization of the paralysed muscles. On June 12th the biceps and brachialis anticus began to recover and the patient could voluntarily flex the forearm. On the 18th sensation returned in the thumb and the dorsal surface of the first phalanges of the index and middle fingers. There was slight power of extension of the hand on the forearm, and some return of sensation on the outer part of the forearm. On the 24th sensation returned upon the inner border of the forearm. Two days afterwards sensation and movement returned in the area of distribution of the ulnar nerve; paralysis of the deltoid nevertheless continued. On the 29th the patient could slightly abduct the arm, and one could distinctly feel the deltoid contract. On July 8th the patient could lift the arm to a level with the shoulder, and by the 26th he was completely cured.

Lanois.—Spontaneous Paralysis of Muscles of Arm.*

A man, aged twenty-two, was admitted into the hospital on May 19, 1881, for pleurisy of the left side and weakness in the arm. An examination of the arm showed a general weakness of all the muscles, especially of the deltoid, biceps, and supinator

* *Revue de Médecine*, 1881, p. 988.

longus. These muscles were also wasted and reacted feebly to the faradic current. By July 18th the patient had improved under faradism to such an extent that he left the hospital.

The recorded cases of idiopathic neuritis owning no cause and affecting the lower extremity are certainly much less numerous than those related in connection with the arm. Indeed, I am not acquainted with a single unequivocal case.

In my opinion, this rarity is probably dependent rather upon insufficient observation than upon their entire absence, and I am disposed to think that not a few of the cases of paralysis attributed to anterior polio-myelitis, are very probably due to a peripheral neuritis. I allude more particularly to those cases of so-called infantile paralysis in which only one leg is affected, both arms being left intact, and in which complete recovery may ensue. Similar cases may be met with in adults, and I have recently seen a young man, aged twenty-two, in whom the muscles supplied by the posterior tibial nerve in each leg have become paralysed and wasted. As yet no treatment has been adopted. In another case with which I am acquainted, the patient, a young and healthy man, suffered for some weeks from paralysis of the peronei, but was completely restored under treatment by galvanism. I do not doubt that many such cases exist, and that in some of them the symptoms of peripheral neuritis are more marked than in others. So far they have been missed for want of sufficient observation and of knowledge of what to look for.

The cases I have spoken of up to the present have none of them shown any marked signs of inflammatory change, but the following description by Dr. Buzzard* of a case of acute idiopathic neuritis affords an example of what I believe to be a very rare affection. Its similarity to cases of traumatic neuritis will be obvious at a glance.

"A single woman, aged twenty-four, was sent to me from the country on Feb. 20, 1883, suffering from loss of power in the right hand, with agonizing pain. Her arm was in a sling, the hand covered up with cotton-wool, and she jealously watched the limb to guard it from the slightest accidental touch, so exquisite was the tenderness. The right hand and forearm had a soddened, puffy, helpless appearance, with swollen fingers and purplish discoloration of the skin in patches, which here and there looked glossy.

* *Lancet*, Nov. 28, 1885.

Her immediate illness had commenced in the preceding August (six months previously) with pain and swelling in the middle finger, which gradually extended to the others, and for some months past her hand had been quite useless. The pain was so constant and severe that she could scarcely ever get sleep at night. She looked extremely ill. It seemed that her business was to help in the household of her father. She had lost her mother from cancer of the liver. There was no rheumatism in the family, but she had been considered to be weak in the chest. A brother was supposed to be consumptive, and a sister had cough. She herself had suffered much from so-called 'rheumatism' in the knee and left hand. Nothing wrong was to be found on examining her chest, and the ophthalmoscope showed no change in the fundus oculi. There was not the least reason to suspect either alcoholism or syphilis. Her temperature was 100° F. On examination, it was seen that the power of extending the wrist was moderately good, but flexion of it could not be performed. There was slight power of flexing the last joint of each finger, and an equally slight power of extending it, and this applied also to the last joint of the thumb. There appeared to be no power in the intrinsic muscles of the thumb and fingers. Examined electrically, the thenar muscles did not respond to either form of electric excitation; but the muscles of the back and front of the forearm were excitable by induced currents, though only when a considerable strength was employed. A detailed examination was not possible, owing to the exquisite sensitiveness of the limb. Warmth was felt as well by the right hand as by the left, but cold was felt best on the left (unaffected) hand. A hair drawn over the skin of the left hand was felt better than on the right. The patient was forced to keep the limb covered up, as the air would start pain, and conveyed a burning, smarting sensation. There was a more or less constant feeling of numbness in the fingers. By way of treatment, the limb was supported by a splint, ice and small flying blisters being applied; nourishing diet was ordered, and opium administered internally. The symptoms, however, continued without any material change, except that in June, after placing her arm in hot water, it became 'spotted' all over, as she described it (for I did not see this), and blisters formed over her fingers. The blisters, apparently of the nature of pemphigus, discharged, and became covered with crusts, which remained when I saw her in July. I lost account of her after this, but have since learned the sequel, which is sad. She

continued to suffer as described during the winter of 1883-84, and in the early spring of 1884 was attacked with acute melancholia with strong suicidal intent, and was confined for six months in an asylum. As described by the superintendent of the asylum, 'her arm at the time of admission was somewhat smaller than the other, with diminished mobility and considerable pain. There was some discoloration of the skin. The arm was supported for a time, and by the end of April it appeared to have recovered its size, and she could use it a little. The pain was not constant, but warmth caused a 'burning feeling,' and cold 'painful rheumatic sensations.' By September she could use the right hand as well as the left. Morphia was administered to her in the asylum until her melancholic symptoms were considerably improved. In October she was discharged, recovered both in her mind and also in her arm, which she used freely and without pain. The only complaint when last I heard of her was that in cold weather the arm ached."

Neuritis from Cold.—Paralysis of the facial nerve is certainly the most common example of neuritis from cold, yet the exact manner in which the nerve is affected is not clearly understood. It is generally supposed that there is an effusion either into the sheath of the nerve or else into the bony canal in which it runs, but I am not aware of any pathological proof in support of either hypothesis.

The most common cause is exposure to a draught, when heated. The paralysis supervenes within a few hours, and presents features which are so well known that it seems to me to be quite superfluous to append any description. The faradic excitability of the muscles is often normal, but may be diminished.

Paralysis of the muscles of the extremities from exposure to cold was formerly supposed to be much more common than is now generally believed. Thus Duchenne* says that he has seen a hundred cases of paralysis of the parts supplied by the musculospiral nerve originating from this cause. No doubt some of these numerous cases were due to exposure, but others were most probably due to pressure during sleep, as in the instances I have already described.

Generally, the signs of inflammation are but little marked, but in a case recorded by Duchenne† the paralysis was "preceded by

* Works, translated for the Sydenham Society by Dr. Poore.

† *Op. cit.*, p. 242.

frightful pain in the region of the musculo-spiral nerve and its branches. At the outset there had been one or two days of fever with burning pain in the affected limb. After three months the pains disappeared suddenly."

The following are good examples of paralysis of other nerves of the arm from exposure to cold :

Lanois.—Spontaneous Paralysis of the Brachial Plexus.*

A man, aged twenty-three, was admitted into the Military Hospital on the 19th of February 1881. His history was that in October 1880 he had slept out of doors, lying on his back. He had felt very cold, and on waking at two o'clock in the morning he found that he could not use his left arm and hand. He had no pain or tingling. The following day there was developed a paralysis which had not increased at the time of his admission. On examination the left hand was found flexed at right angles upon the forearm, and was slightly inclined towards the ulnar side. The thumb was extended, the other fingers were incompletely extended, and the little finger was flexed. The extensor muscles were paralysed, but not completely. The supinator brevis was paralysed, but the supinator longus was not involved. The muscles supplied by the median and ulnar nerves were paralysed, but again not completely so. All the affected muscles were atrophied. Electrically examined, there was found to be faradic sensibility and contractility, but a strong current was required to produce muscular contractions. To galvanism there was no reaction, but the battery which was used was a feeble one. There was great loss of sensibility in the whole of the forearm. There was no exaggeration of tendon reflexes or sensation of pain or numbness. The hand was cold and the skin white. There were no other trophic lesions.

The patient was treated by massage, faradization, and warm baths, but as late as May 14th there was no material improvement.

Panas.†—Paralysis of the Ulnar Nerve resulting from Exposure to Cold and Overwork.

The patient was a man, aged twenty-four, who stated that he had been in a storm at sea, and had undergone great fatigue in

* *Revue de Médecine*, 1881, p. 988.

† *Archives Générales de Médecine*, 1878, vol. ii. p. 18.

rowing before he reached land. At the time he noticed that the right elbow was swollen, and he felt tingling sensations in the hand and forearm for more than a month afterwards. Six months later he noticed weakness of the hand, which steadily increased. The paralysis had existed for two and a half years before he came under notice, and was rapidly cured by means of galvanism.

The onset of the paralysis in these cases is usually sudden, and is frequently noticed on awakening from sleep. The duration of the paralysis varies, but the prognosis of ultimate recovery is good, almost all the patients whose cases are recorded having been ultimately completely restored to health.

Nerve Changes in Perforating Ulcer.—In writing on the surgical aspects of neuritis the subject of “perforating ulcer” is one which demands a passing notice, for it is now generally acknowledged that this form of ulcer is in most cases dependent on some nerve lesion.

The pathology of perforating ulcer received but little attention in England before the publication, by Messrs. Savory and Butlin, of their well-known paper in the year 1879,* although Continental writers, and especially French surgeons, had published many important monographs on the subject. Savory and Butlin reported several very typical cases, and demonstrated the disease of the tibial nerves which is now recognized as neuritis, pointing out very clearly at the same time the relation of the lesion in the foot to the degeneration of the nerves.

Fresh interest was awakened in the matter in the year 1881, by a paper of Messrs. Ball and Thibierge, of Paris, read at the meeting of the International Medical Congress in London,* for in this communication it was demonstrated that perforating ulcer is peculiarly liable to occur in patients suffering from tabes dorsalis. Since that time indeed the presence of a perforating ulcer has always been looked upon as one of the common symptoms of this affection of the spinal cord, and it has further been shown that in these patients there is not only the typical degeneration of the postero-lateral tract, but also a peripheral neuritis.

I have myself examined the nerves and spinal cord of a case in which the anterior and posterior tibial nerves showed typical and advanced neuritis, whilst the cord also exhibited the usual changes

* *Trans. of Roy. Med. Chir. Soc.*, vol. lxii. p. 373.

† *Trans. of Int. Med. Cong.*, vol. ii. p. 52.

found in tabes. It is indeed clear that perforating ulcers may complicate not only tabes, but other affections of the cord or of the peripheral nerves—*e.g.*, the nerve lesions characteristic of leprosy; and I have seen a well-marked example of the affection in a case in which the spinal cord had been injured many years previously by a fracture of the dorsal spine, resulting in partial paralysis of the lower extremities.

It is scarcely necessary to describe at length the clinical characters of a disease now well known, and I shall venture to say but few words on the subject.

In most cases the ulcer is situated on the ball of the great toe, and is preceded by much thickening of the epidermis and the formation of a corn. After a variable time the centre of the corn breaks down, and an opening forms, which at first appears minute and trifling, but which nevertheless, even at a very early stage, will be found to lead into a sinus of much greater depth than would appear probable from the external appearances. The ulcer now increases both in surface and in depth, and soon reaches the bone and opens the metatarso-phalangeal articulation. From the commencement the ulceration causes but little pain except when the parts are pressed upon in walking, and then, if the joint be involved, the pain is often severe. In some cases the skin around the ulcer is red and inflamed; in others cold, clammy, and the seat of profuse perspiration; in the latter class of cases there is also sometimes anaesthesia of the skin in the neighbourhood of the ulcer. In many cases the disease is symmetrical, and in some patients is found on other parts of the sole than the ball of the great toe.

As to the course run by perforating ulcer there has been hitherto much variety of opinion, and until quite recently it has often been stated that such ulcers never soundly heal, and should always be treated by amputation. For my own part, I am quite clear that such is hardly ever the case. I have during the past six years seen more than thirty patients with perforating ulcers, and in only one of them was amputation required, for in all the others cicatrization was readily obtained. In one case recently under my notice, in which the patient had tabes and Charcot's disease of each knee-joint, the perforating ulcers, which were in him symmetrical, remained soundly healed so long as his habits were temperate; but he was himself well aware that the least indulgence in alcohol at once caused the ulcers to again break out, and I completely satisfied

myself of the accuracy of this statement. Considering the present state of our knowledge as to the neuritis of the nerves of the legs caused occasionally by alcohol, the effect of drink on the ulcers in this patient is not only of some interest but also of practical importance, and in future I shall certainly take care that in the treatment of these cases alcohol is withheld. As to other treatment there is little to say. Rest in bed, cleanliness, the application at first of poultices, and the removal of the dry dead epidermis, followed by the use of powdered zinc oxide and starch, or zinc oxide and calomel, or boracic acid, are usually all that is required, whilst the subsequent application of strapping applied so as to relieve pressure will generally prevent a return of the trouble. The opening up of the metatarso-phalangeal joint is not by any means so serious a complication as might be supposed, and I have often seen patients recover with a good and useful foot after grating in the joint was well marked.

Diabetic Neuritis and Diabetic Gangrene.—The connection of diabetes with gangrene is a fact well known to all surgeons at the present day, but the cause of the connection is not, I think, generally considered to be clear. I believe myself that the gangrenous process in these patients is frequently, at any rate, the result of neuritis, for I have in several cases had good evidence of the presence of nerve lesions in patients with diabetic gangrene.

I would, however, first of all point out that by no means all the cases of gangrene in which sugar is found in the urine are to be classed as cases of "diabetic gangrene," for in a very large number of patients with simple senile gangrene sugar may be found at times, and much confusion has been caused by classing these cases of transient glycosuria with others of definite diabetes. This point has been very clearly brought out by Mr. W. G. Spencer in a recent article in vol. iv. of the *Westminster Hospital Reports*.

My attention was first directed to the possible neurotic origin of diabetic gangrene by noticing that it commonly began in the sole of the foot, and that it in some cases was definitely preceded by the formation of a perforating ulcer. I further found that in some cases there was anæsthesia of the neighbouring skin with absence of knee jerk, and in all typical cases not only is there no evidence of blocking of the arteries, but the gangrene is much more moist than is senile gangrene, and spreads more rapidly.

The following are brief notes of cases in which the gangrene began as a perforating ulcer :

J. J., a woman, aged fifty-eight, was admitted into St. Bartholomew's Hospital, under the care of Mr. Savory, on Dec. 6, 1886. Six weeks previously she had come to the Casualty Department and had been seen by the house surgeon, who found her suffering from a typical perforating ulcer of the ball of the right great toe. She then stated that she had had a corn for nine months or more, and that it had festered. On her admission to the hospital the whole of the anterior part of the foot was found to be in a state of moist gangrene. Her skin was dry, her tongue and lips red and cracked, and her urine contained much sugar. She passed eight pints per diem, and said she had passed large quantities for some years past, and had suffered much from thirst. The symptoms of diabetes dated from a fracture of the skull. The patient died on Dec. 11th in a state of coma, but no post-mortem examination was permitted.

T. R., a man, aged forty-four, was admitted into St. Bartholomew's Hospital, under Mr. Langton, on March 26, 1886, with a perforating ulcer of the left great toe. He had had a corn for several months and an ulcer for nine weeks. The skin around the ulcer was partially anæsthetic and perspired profusely. The knee-jerk on each side was quite absent. His urine contained much sugar, and was passed in large quantities. He gave a clear history of diabetes. After a week, and in spite of treatment, the skin around the ulcer became gangrenous, and soon the whole of the foot passed into a similar condition. The gangrene was of the moist variety, and the parts were very foul. On May 20th Syme's amputation was performed, but the flaps were attacked by the gangrenous process, and on the 26th the patient died. No post-mortem examination was allowed.

A man, aged fifty-six, was admitted into St. Bartholomew's Hospital, under Mr. Langton, on July 4, 1887, with an ulcer under the fourth toe of the right foot, which he attributed to treading on a rusty nail. The skin around the ulcer was gangrenous, and the urine contained much sugar. The patient died on July 6th, and a post-mortem examination showed that the tibial vessels were healthy, but that the kidneys were granular.

A man, aged forty-four, was admitted into St. Bartholomew's Hospital on March 27, 1889, with gangrene of the fifth toe of the

left foot. He stated that for several months he had had a corn on the ball of the little toe, and that without pain it began to fester a few weeks before his admission to the hospital. He had suffered from excessive thirst and frequent micturition for some time, and the urine was loaded with sugar and passed in very great quantities—from six to eight pints a day.

An examination of the foot showed a foul perforating ulcer, with gangrene of the little toe and anæsthesia of the surrounding skin. Pulse in each tibial good, knee-jerks quite absent on each side.

An old woman was admitted into St. Bartholomew's Hospital, under the care of Mr. Morratt Baker, on Feb. 2, 1887, with moist gangrene of her left foot of a few weeks' duration, commencing in the sole. The pulse in the tibials was good. The urine was passed in large quantities and contained much sugar. On Feb. 15th amputation was performed, but the flaps sloughed and the patient died. An examination of the tibial nerves showed much degeneration of the tubules, with complete destruction of many, and a considerable increase of connective tissue. The tibial vessels were healthy.

But although I am of opinion that peripheral neuritis plays an important part in the causation of diabetic gangrene, I do not wish to imply that the gangrene is due to this alone. I think that the perforating ulcers which form in these cases are certainly due to the nerve lesion, and that they are found at the seat of pressure or irritation in tissues whose vitality is lowered by insufficient nerve supply, as in these more common cases of perforating ulcer which complicate *tabes dorsalis*. The gangrene, however, which ensues is probably due to some altered state of the tissues or the blood, for it is liable to occur in any part of the body in which a wound is inflicted or an open sore caused, and is well known to ensue in a certain proportion of operations performed on diabetic patients. If this be true, then the nerve lesion may be looked upon rather as the predisposing than as the final cause of the gangrenous process, and this I think is the proper view to take. The matter is one of some practical interest, for I should give a much worse prognosis in a case of perforating ulcer complicated by diabetes than in other cases where no sugar was found in the urine.

Peripheral Neuritis in Raynaud's Disease.—The pathology of Raynaud's disease is yet obscure, but I think there is

good evidence that in some cases at least the peripheral nerves are at fault. And indeed it has always appeared to me that from a *prima facie* point of view the neurotic origin of this form of gangrene is probable.

We know well that the calibre of the vessels is regulated by the nervous system, and that in Raynaud's disease there are periods of imperfect blood-supply which must be due to some contraction of the arteries. It has been shown that in such cases there are never any thrombi or emboli, and that the vessels themselves are healthy. There is also no reason for believing that the amount of blood in the body is insufficient in quantity or materially altered in quality, and the transient character of the attacks of coldness or of gangrene would alone negative such an opinion.

On the other hand, we know that in cases of peripheral neuritis gangrenous patches may occur on the skin, and that after nerve section or pressure on nerve-trunks similar results may ensue. I have seen cases of gangrene of the finger-tips after nerve section which would have done admirably well for examples of Raynaud's disease, and the case mentioned on page 446 would have been another good example.

But in this matter we are not left simply to speculation. Dr. Wigglesworth has described a case of Raynaud's disease in a woman, aged twenty-six, in which after death he found typical peripheral neuritis with increase of fibrous tissue and atrophy of nerve-tubes in many of the nerves,* and in the recently published New Sydenham Society's edition of Raynaud's works on this subject, Dr. Barlow, the translator, refers to two cases by Pitrés and Vaillard in which similar changes were found, whilst a still more recent case is recorded by Dr. Affleck in the *British Medical Journal* for Dec. 8, 1888. Moreover, in a well-known case by Dr. Southey,† in which a very large surface of the skin of the limbs and trunk became gangrenous, I found a very widespread peripheral neuritis, although at the time I made the sections (now some years ago) I did not sufficiently appreciate the changes in the nerves or their importance. It is of course not probable that a neuritis is present during every slight attack of cold fingers and numbness common in all patients the subject of the malady in question, but it is in my opinion probable that there is always at least a functional nervous disturbance, which occasionally culminates in a true neuritis.

* *Trans. Path. Soc. of Lond.*, vol. xxxviii. p. 61.

† *Path. Soc. Trans.*, vol. xxxiv. p. 286.

Additional evidence is, however, wanting in this direction, and I do not propose to pursue the matter further at present.

Affections of the Nerves in Leprosy.—It is now a well-recognized fact that many of the lesions of leprosy are due to disease of the nerves. Thus, the patches of anæsthesia, the wasting and paralysis of muscles, the ulcerations and gangrene of the fingers and toes, evidently come under the head of “trophic lesions.” Post-mortem examination, moreover, supplies abundant proof of nerve disease, and demonstrates the growth of fibrous tissue in the nerves, either in the form of a general thickening or as definite tumours, and the microscope further shows that in consequence there is degeneration of the nerve-fibres themselves. The subject of leprosy, however, is not one which can be adequately considered in a work devoted simply to the nerves, and I do not therefore propose to enter further upon the consideration of a disease which is now fully described in all works on surgery.

Syphilitic Neuritis—The implication of the peripheral nerves in syphilis has only been noticed of late years, although, considering that the brain and spinal cord are each affected with comparative frequency, the probability of syphilitic neuritis might readily be deduced.

At present we have scarcely enough knowledge of such cases to attempt any general description of their clinical features, but from the little we do know we may say that neuritis may occur in either congenital or acquired syphilis, and that it may implicate one nerve-trunk or many. Like other syphilitic lesions, it appears to yield to mercury and iodide of potassium. In its symptoms it does not differ from the other forms of non-traumatic neuritis already described.

The following case by Dr. Ormerod is a good instance of localized neuritis in congenital syphilis:

Ormerod.—Enlargement in the Median Nerve in a Case of Congenital Syphilis.*

In a woman, aged twenty-three, the left median nerve in the upper arm was thicker than a quill. The patient was shown at the Pathological Society on Jan. 4, 1881. The muscles supplied by the median nerve were wasted, and the last two joints of the index and little fingers and the last joint of the thumb were anæsthetic.

* *British Medical Journal*, 1881, vol. i. p. 88.

The skin of the last joint of the index finger had been red, glossy, and ulcerated, but these conditions had passed away under treatment. There had been an attack of pain in the nerve five years previously, but this had passed off, leaving no permanent damage. Two and a half years previously the pain had recurred, leaving the present condition. The patient presented several unequivocal signs of congenital syphilis.

In the next case a neuritis of the sciatic nerve appeared coincidentally with a node in a case of acquired syphilis :

CASE I.—*Buzzard.*—Cases of Syphilitic Neuritis.*

A man, aged thirty-one, applied at the Hospital for Epilepsy on account of great pain in the right leg, with difficulty in walking. The pain radiated along the course of the trunk and branches of the sciatic nerve. There was a tender spot where this nerve quits the pelvis and another in the popliteal space. The limb had wasted, and the patient said that he had lost two stone in weight since the beginning of his illness, eighteen months ago. The original illness had begun with a severe attack of diarrhoea, following exposure to cold and wet. Severe pain then attacked him behind the hip-joint, and from that time he had never been free from suffering. He could not sit or stand without increasing his suffering, and he never obtained an hour's sleep at a time. There was a doubtful history of syphilis, and on the front of the right femur was a swelling like a node. Under treatment by iodide of potassium the symptoms entirely subsided and the node disappeared.

In the following case† neuritis of the larger number of the peripheral nerves, resulting in almost complete paralysis, occurred in a syphilitic patient :

“ W. H., a working man, aged forty-four, of previous good health, was brought to me at the hospital in Jan. 1873, in the following condition. He had double facial paralysis, total absence of power of voluntary contraction in the muscles of either leg, the grasp of both hands almost entirely lost, and partial paralysis of respiration and deglutition. There was incomplete paralysis of the right external rectus muscle and of the soft palate, especially on the left

* *Lancet*, 1879, vol. i. p. 289.

† Buzzard, *Lancet*, Dec. 12, 1885.

side. There was but little movement of the diaphragm, and the intercostal muscles were likewise acting so imperfectly that the patient could not lie down in bed. His sterno-mastoid and trapezii muscles acted freely. Cutaneous anæsthesia was more or less general throughout the trunk, extremities, and face—the tips of the fingers being especially numbed. The plantar reflex was absent in each foot. There was slight power of voluntarily contracting the muscles on the front of each thigh, but he was unable to contract in the least those on the front of either leg below the knee. A sense of numbness and weight was complained of in each leg, and occasionally a ‘throbbing ran down the left thigh and calf.’ For the first two or three weeks also he had suffered from ‘pins and needles’ in his legs. But at no time apparently had there been any actual pains in his extremities or involuntary muscular contraction. The power of the sphincter ani was normal, that of the bladder impaired to a slight extent. The muscles about the mouth showed the reaction of degeneration. In those of the arms the reaction of faradism was greatly diminished, whilst in those of the legs, below the knees, it was quite absent; in the left thigh it was greatly diminished. (The right lower extremity was lame and wasted from an old attack of infantile paralysis.) But in no part of the upper or lower extremities was there increased action to slow intermissions of the galvanic current. In the face, however, this was marked. The facial muscles reacted to interruptions of a current from six cells (Stöhrer). His attacks had commenced one month previously with numbness in the finger-ends, followed on the same day by weakness in the legs, which increased next day and was then accompanied by numbness about the calves, thighs, and buttocks. The weakness increased day by day, and a week after the beginning of his illness he had the sensation of a tight band round his abdomen. A few days later he could use neither arms nor legs. The difficulty of swallowing was not observed till a fortnight after the onset. There had been no fever. There was nothing abnormal in the mental condition, nor in the heart, lungs, and kidneys. The patient was at once admitted and placed on a water-bed. For twenty-four hours his condition was one of imminent danger from the state of respiration. As there was a syphilitic history, he was treated with iodide of potassium, and later with mercury. He soon began to improve, and in six months was able to resume his employment. A few months later I showed him at the Clinical Society, entirely recovered.”

I have also recently seen a man, aged fifty-four, who had suffered from syphilis for many years, in whom a gradual paralysis of the parts supplied by the ulnar nerve commenced ten years before he came under my notice.

I found the hand clawed, the interossei muscles and those forming the ball of the little finger extremely wasted, and very definite atrophy of the ulnar side of the forearm. The skin supplied by the ulnar nerve was almost quite anæsthetic. The ulnar nerve itself could be easily felt behind the elbow as a thick, hard cord, not less than four or five times its natural size, the thickening extending along the trunk for about two inches. It was very slightly painful or tender. I could not persuade the patient to continue treatment, and when I last saw him, six months later, his condition was unaltered.

Rheumatic Neuritis.—It would appear that rheumatism, which spares neither joints nor muscles, may also affect the nerves. Whether some of the cases of so-called muscular rheumatism are not really cases of neuritis I think we may well doubt. For my own part, I think they are, and those instances which are not uncommon of muscular paralysis and wasting in rheumatic patients, seem to me to strongly favour such a view. For not only may the muscles be paralysed and waste in such patients, but their reaction to faradism may be much impaired. Perhaps further investigations may bring more light to bear on the subject.

In the following case a neuritis of the sciatic, with muscular wasting and diminished faradic contractility, was supposed by Dr. Buzzard to be due to rheumatism:—

CASE II.—*Buzzard.*—Rheumatic Neuritis.*

The patient was a man, aged sixty-two. Two months before coming under notice he was attacked with severe pains in the lumbo-sacral region and about the hip. In the course of three days he lost the use of his right leg, and suffered from “dragging” pains in the thigh and leg. Three days before he came to the hospital the left leg was attacked by similar pains and became weak. He was found to be in a worn and haggard state, unable to walk, and in great pain. The faradic excitability of the right thigh was much diminished and the muscles were wasted. There was some tenderness over the lumbar vertebræ. Patellar reflex normal in

* *Lancet*, Dec. 12, 1885.

quality; no ankle clonus. Under treatment by 10-grain doses of iodide of potassium the patient quickly convalesced.

In the next case it is perhaps doubtful whether the symptoms were due to rheumatism or to gout. I think, however, that they certainly point to a neurotic origin.

Anæsthesia and Coldness of the Tip of the Little Finger, with Pain.

J. B., aged sixty-seven, was admitted into St. Bartholomew's Hospital on Dec. 31, 1884. He had suffered from rheumatism. For some weeks past his little finger had been quite anæsthetic, cold, and shrivelled. On examination, the little finger on the left hand was found to be white, shrivelled, and numb. It could, however, be raised to the natural temperature when wrapped in cotton-wool. When cold it was painful, but if kept warm he suffered no pain. The patient was treated with quinine and a liberal diet. The little finger was kept warm, and the arm was galvanized. No improvement followed. The electrical reactions were normal.

Several interesting cases of a similar nature have also been recorded by Dr. Hadden.* In one of these a woman, who had suffered from acute rheumatism, had glossy skin, anæsthesia, and muscular wasting; and another patient, a man, had anæsthesia of parts of the hands, arms, and feet, with fibrillar twitchings of the leg muscles.

Gouty Neuritis.—Had it not been for the recently published lectures by Dr. Buzzard I should not have alluded to this variety of neuritis, for I have neither seen a case nor have I read of one. Having no knowledge of the subject myself, I shall therefore merely quote the following extract from Dr. Buzzard,† from which it will be seen that our knowledge of this subject is yet very vague:

“Cases of this description are not uncommon, and frequently give rise to a great deal of anxiety. A gouty patient who is past middle age is prone, as we well know, to disease of the blood-vessels and kidneys. An attack of numbness and paralysis in a limb, in these circumstances, is naturally liable to be referred without hesitation to a central lesion—hæmorrhage or thrombosis.

* *Clinical Society's Transactions*, vol. xviii.

† *Lancet*, Nov. 28, 1885.

That this supposition is far more often than not correct is certainly the case, but every now and then we meet with examples like the one described, which show the necessity of bearing in mind the possibility of a peripheral cause in such an attack. The question of the possibility of gout causing neuritis was referred to by Mr. Hutchinson in the Bowman Lecture at the Ophthalmological Society last year. He adduced some instances which appeared to point to neuritis of the optic nerve originating in gout, as well as others suggesting the occurrence of neuritis in other parts of the nervous system from a similar cause. I have very little doubt that neuritis is not seldom due to the presence of gout; the difficulty of proof is of course extremely great. I cannot lay claim to adduce anything which is absolutely positive upon this point, but some clinical observations, and especially certain electrical examinations which I have made, appear to lend considerable strength to this view.

"An old friend of mine, a member of our profession, sent for me a few months since in a state of alarm, having woke up in the morning with numbness in the arms, which was at first slight, and affected the side on which he was lying, the left much more than the right. In the course of a few hours it had grown rapidly worse, and was accompanied by pain in the shoulders. There was considerable loss of power in the arms. I found that he had had a characteristic attack of gout in the ball of one big toe some six years previously, and more than once had suffered badly from lumbago. He had been liable to pains in the shoulders for many years, and on several occasions had been troubled with sciatica. I was able to reassure him unreservedly, and treatment directed entirely to his gouty habit brought about immediate improvement and complete recovery in no great time.

"It is not certain that we are justified in applying the term 'neuritis' to such cases as this, with the small amount of evidence of the pathological condition which is usually to be obtained. The contrast as regards the number and severity of the symptoms with such a case as that of the young woman which I first described, is very striking; but it appears to me that we have only to imagine a like affection of the nerves, though comparatively of very slight kind, to explain the symptoms of nerve lesion observed in gouty patients. Not only are both the motor and sensory fibres often involved in these circumstances, but it frequently happens that there are signs of the vaso-motor fibres

being likewise affected, and causing coldness of the extremities and discoloration of the skin. I lately saw a case in which, along with pains which were almost universal, and which there was strong evidence to show were dependent upon a gouty habit, there was an extraordinary amount of œdema of the lower extremities. This extended half-way up each leg. As there was nothing in the state of the heart, kidneys, or liver to explain the dropsical condition, it seems quite possible that the cause of it, as well as of the pains, may lie in neuritis, which involves both sensory and vaso-motor fibres.

“Electrical examination will often give a good deal of support to the view that these are cases of slight neuritis:—

“A lady, aged fifty-two, complained that her left hand would close during the night, and that she could not get it open again without dreadful pain at the wrist and up the fingers. It would be found icy cold. Some time previously, her left arm, and to a less extent the right arm and the toes of either foot, would ‘go to sleep.’ On examination she complained of pain, pricking, and tingling in the thumb and first three fingers, as well as slight numbness and coldness in the toes. Occasionally there would be a dart of pain down the arm and finger. She was a healthy-looking woman, who presented no signs of degenerative changes. Her tongue was clean. She had usually enjoyed good health, except for what she called rheumatism and occasional attacks of indigestion. In these there would be acid risings, with bilious vomiting and palpitation of the heart. She was troubled also sometimes with flushes of heat, and according to her account her stomach was easily put out. Her urine was described as being thick. Examination with induced electrical currents showed that the intrinsic muscles of the left thumb were less excitable than those of the right, and to a marked degree less excitable than the corresponding muscles of a healthy subject. Inquiry into the history elicited that the patient’s father had suffered badly from gout, and that she herself drank a great deal of sherry and occasionally also whisky.”

CHAPTER XXVI.

MULTIPLE NEURITIS.

Alcoholic Neuritis.—The subject of alcoholic paralysis is one that lies almost entirely within the domain of medicine, yet not so completely but that I may venture to allude to it.

Until within very recent years the paralysis which was noticed in patients who were heavy drinkers was attributed to disease of the spinal cord, and although some cases may be due to this cause, yet we are now in a position to affirm that such paralysis may be present in its worst and most acute form, and may lead to fatal results in patients in whom no disease of the spinal cord exists. Further, in such cases disease of the nerves has now been demonstrated, and it has been shown that the nerve may either be the seat of genuine chronic inflammation with formation of fibrous tissue and constriction of the nerve-tubules, or else of simple degenerative changes with gradual destruction of the axis cylinders and white substance of Schwann. Alcoholic paralysis is usually described as affecting all the extremities, yet I am inclined to believe that in some cases a purely local neuritis may be due to alcohol, and in this opinion I am strengthened by the experience of Dr. Steavenson, the electrician to St. Bartholomew's Hospital. He has kindly placed at my disposal the notes of several patients who have been under his treatment for localized neuritis, with resulting paralysis, in whom, beyond a clear history of alcoholic intemperance, no cause could be discovered. In these cases the muscles most usually affected were the peronei and the tibialis anticus, and as confirmatory evidence it is noticeable that these are just the muscles most markedly affected in cases of multiple neuritis due to alcohol. Further, the diminution of faradic irritability and the reaction of degeneration makes it almost certain that in them there was a genuine neuritis and not a mere myopathy. The multiple form of neuritis due to alcohol does not very

materially differ in its onset and symptoms from the other cases of multiple neuritis which own no such cause.

I shall therefore quote the following cases, which I have selected as typical of such varieties as may occur, and shall then proceed to deal with them together with the other forms of multiple neuritis :

“ My personal observation of the disease dates from a case which I attended in 1870 in consultation. The patient was a lady who had for years been addicted to great alcoholic excesses, consuming large quantities of brandy. When called to her she was in bed suffering from considerable loss of power in the upper and lower extremities. The hands were dropped at the wrists, and she could not extend them. The feet, too, were likewise in a dropped condition, and there was no power of dorsal flexion. There was much mental disturbance, and such loss of memory that the patient could give no intelligible account of the duration of her illness. She could move her arms and raise the knees, though with difficulty. The functions of the bladder and rectum were not interfered with. Her naked feet projected from the foot of the bed-clothes, and she would not allow anything to be laid upon them, so exquisite was the tenderness of the skin. Her constant complaint was of the agonizing pains in the legs, ‘as though the veins were filled with molten lead,’ and she appealed piteously to those around her for relief from this suffering. She was placed in charge of two nurses, who gave her no more than the very small amount of stimulant which was allowed, and under careful feeding and treatment her pains got rapidly less. There was much muscular atrophy of the hands and forearms and the anterior tibial muscles, with complete ‘reaction of degeneration.’ Her hands assumed the typical form of the ‘*main en griffe*’ of Duchenne.’ In the course of a little more than a year she had recovered so far as to be able to go about by herself, and the movements of the hands also were practically restored. The first use which she made of her liberty was to visit a succession of taverns, and inaugurate a debauch, which terminated her existence in the course of a week or two.”*

Hadden.†—*Alcoholic Paralysis.*

A woman, aged thirty-three, was admitted into St. Thomas's Hospital on April 7, 1883. She had always been a heavy

* Buzzard, *Lancet*, Dec. 12, 1885

† *Trans. of the Pathological Soc.*, vol. xxxvi. p. 49; *British Medical Journal*, Oct. 25, 1884, p. 813.

drinker, but especially so for the last twelve months. She had been married thirteen years, but had no children. Four months before admission she began to have pain in the head and twitching of the face and hands. She had fallen down unconscious several times. Ten days before admission she lost the use of her legs. On admission the legs and thighs were cedematous, and she had retention of urine. The legs were almost powerless. Patellar tendon reflex was absent. Sensation was fairly good. She soon became delirious. The paralysis of the legs and arms became marked, and the muscles failed to respond to the strongest interrupted current. Sensation was noticed later on to be decidedly delayed. The patient died. The post-mortem showed no changes in the brain or spinal cord. The nerves were not examined.

Hadden.—Alcoholic Paralysis.*

A woman, aged forty-two, who had been drinking freely and had had delirium tremens, was admitted into St. Thomas's Hospital. Weakness of the legs came on three months before admission, and for the last six weeks she had not walked without assistance. On admission she complained of severe pains, which started in the great toe and passed up to the hip, coming on in paroxysms. There was no loss of control over the bladder and rectum. She slept very little, and had delusions at night. The arms were wasted, and there was wrist-drop on each side. All the muscles of the arms were weak, but the extensors were weaker than the flexors. The reflexes were absent. Muscular sense normal: sensation normal. Great weakness of the muscles of the trunk. Voice feeble. No anæsthesia of the trunk and no superficial reflexes. Legs emaciated and painful when touched or moved. She could move them slightly, but they were kept drawn up. The power of localizing sensory impressions was impaired. No affection of the cranial nerves. Later, the improvement of sensation was more general, and the shooting pains persisted. Before death a number of bullæ appeared on the limbs. The electrical condition of the muscles and nerves was unfortunately not ascertained. The patient died. The post-mortem showed broncho-pneumonia and cirrhosis of the liver. Brain atrophied in the frontal region. The spinal cord, examined microscopically, was found healthy. In the right sciatic nerve the nerve-tubes were much reduced in size. The endoneurium and neuritis

* *Trans. of the Pathological Society*, vol. xxxvi. p. 51; *British Medical Journal*, Oct. 25, 1884, p. 813.

lemma were much thickened, but not the perineurium. In parts there were areas made up of thickened connective tissue and axis cylinders. The change was more advanced in the centres of the bundles, where there were large strands of new connective tissue. There was no segmentation of the myeline. The lesion found was therefore perineuritis or cirrhosis, and the atrophy of the nerve elements was a secondary condition. The right median nerve showed similar but less marked changes. Between the fibres of the gastrocnemius there were rows of deeply stained nuclei, in some parts taking the place of the muscular fibres. The muscle corpuscles were increased. The fibres were atrophied, and showed some early granular change.

Idiopathic Multiple Neuritis.—The multiple neuritis which results from alcohol differs but little, as I have already mentioned, from other cases of multiple neuritis which own no such cause, and which, for want of a better name, are often called idiopathic. I believe that the earliest published case of this affection is recorded by Duménil.* The patient was a man, aged seventy-one, who, after suffering from numbness of the feet and hands for two weeks, was suddenly seized with weakness in the left arm and leg, shortly followed by general paralysis and atrophy of the muscles of both the upper and lower extremities, and in four and a half months by death. A post-mortem examination showed that the brain and spinal cord were healthy, but that the nerves were the seat of degenerative changes. Two years later another similar case was reported by the same writer,† but in it the spinal cord also presented degeneration of the nerve-fibres.

Since this time cases have been published by Eichorst, Leyden, and Joffroy, and after 1879 by numerous observers. From these I have selected such as appear to me to give the best clinical and pathological insight into the disease in question.

Eichorst.‡—A man, aged sixty-six, after suffering for some weeks from symptoms of quotidian ague, was suddenly seized with severe pain and paralysis of the left superficial peroneal nerve. The limb sweated, felt warm, and the skin was very red. Very soon there was cutaneous anæsthesia, and in twenty-four hours both the affected nerve and the muscles supplied by it ceased to

* *Gazette Hebdomadaire*, 1864.

† *Ibid.*, 1886, No. 4.

‡ *Virchow's Archiv*, vol. lxi.

respond to the induced current. After a week the deep peroneal nerve on the left side, the crural and sciatic nerves, those of the left forearm and upper arm, and those of the right arm were attacked. The paralysed limbs became œdematous, pin-point hæmorrhages appeared on the forearm, and two weeks later there was albuminuria. Twenty-four hours before death there was complete blindness, followed by unconsciousness and coma. At the post-mortem examination the brain and spinal cord were found normal, but the peripheral nerves were everywhere extensively diseased and degenerated.

In 1879, Joffroy* published several cases, the most important of which is the following :

A woman, aged thirty-three, suffering from phthisis, was admitted into hospital with paralysis of the lower limbs. The paralysis spread upwards, but the senses of touch, pain, and temperature remained normal. There was no ataxy of the hands, but the patient lost all knowledge of the position of her feet. Twenty days later her arms were affected with muscular tremors, atrophy, and incoördination of the muscles. She died of phthisis, and a post-mortem examination showed degeneration of the peripheral nerves, but the brain and spinal cord were healthy, except for some chronic cerebral meningitis.

*Grainger Stewart.—Paralysis of the Hands and Feet from
Disease of the Nerves.*

CASE I.—J. I., a clerk, aged fifty-two, was admitted into the Royal Infirmary, Edinburgh, Feb. 18, 1880, complaining of weakness, stiffness, and pains in hands and feet, which had lasted for six weeks. His father had died from hemiplegia at the age of eighty-five. He had himself been temperate, and lived under healthy conditions. He had had no important disease prior to the commencement of the illness for which he sought advice. He stated that in the beginning of Dec. 1879 he fell down a stair, and was considerably bruised and shaken. On the following day he had some rheumatic pains, which came and went during the succeeding week. About ten days or a fortnight later he began to experience a feeling of tingling and numbness in his hands and

* *Archives de Phys.*, vol. vi. p. 172; quoted by Stewart, *Edinburg Medical Journal*, 1884.

feet, with stiffness in the joints of the hands, and a difficulty in grasping and in walking, swelling of the feet and hands, and severe cutting pains both in the hands and the feet. All these symptoms gradually increased in severity until admission. On admission he was pale but not cachectic-looking. Temperature in right axilla, $99.^{\circ}8$; in left, $99.^{\circ}2$. There was no important abnormality excepting in the nervous system. Sensory functions: He complained of severe cutting pain of an intermittent character in hands and feet, increased on pressure, especially of palmar or plantar surfaces, and aggravated by movements of the body, such as lying over on his side or bending his back. With the pain there was a feeling of numbness, but the tingling sensation of which he had previously complained had disappeared. There was no girdle-pain, formication, or giddiness. Sensibility to touch was greatly diminished in both hands, slightly so in the forearms, normal above the elbows. It was also greatly diminished and delayed in both feet, and to a less extent in the legs. Sensibility to heat and tickling were correspondingly affected. The perception of painful impressions was delayed, but felt acutely, a distinct interval elapsing between pinching the hand and its perception; but a slight pinch was felt to be very painful, and the pain persisted longer than normal and set up considerable reflex movements. The muscular sense in the hands and feet, as tested by pointing and by the application of weights, was diminished, but the sense of pressure still more so. Sight, hearing, taste, and smell were all normal. Motor functions: The organic reflex functions were normal; the skin reflex was absent when slight stimulus was applied to soles, but exaggerated and tending to become general and painful when the stimulus was strong. Patellar tendon reflex was lost. Voluntary motion was greatly impaired in the hands and feet, all the groups of muscles being weakened, but those of the fingers and toes completely paralysed. The muscles responded to some extent to the interrupted current, and in proportion to the degree of paralysis the result was feebler. Vaso-motor and nutritive functions: There was glossiness of the skin over the backs of the fingers, and some appearance as of bruises over the toes, but there was no œdema. The muscles were diminished in volume. The acute pain which attended passive movements of the hands and wrists, as well as of the feet and ankles, was not associated with crackling or other evidence of changes of joints. There were no

fibrillar twitchings of the muscles. Cerebral and mental functions were normal. The cranium and spine were also normal. The treatment at first was by means of the liquid extract of ergot (℞ every four hours), and afterwards by the application of the interrupted current to the paralysed part. A degree of improvement soon manifested itself, and on May 26th, three months after admission, the condition was as follows: Pain had disappeared, numbness continued, but to a less extent. It was more marked in the right than the left hand. Sensibility to all kinds of impressions correspondingly impaired. Motor power, although still diminished, greatly better. The muscles of the affected districts much wasted; and though the pain had disappeared from the joints, there was a good deal of stiffness.

On July 15th the sensibility was almost normal. The patient could distinguish the weight and pressure of a half-sovereign from that of a sixpence put into his hand. Skin and patellar tendon reflex were normal. Voluntary motion is slowly returning, the patient being able now to write his name with a little effort, and to stand, although not yet able to walk.

On Sept. 23rd the sensory functions were normal, the skin and patellar tendon reflex rather exaggerated. Voluntary movements of hands were almost completely normal, except in respect of flexion of the distal phalanges. Patient could walk about quite well, but moved the feet *en masse*, the toes playing imperfectly, although he could move them when sitting. The skin was better nourished, the nails much curved. The muscles of the arms and legs, which had been greatly wasted, were gradually recovering their normal volume.

CASE II.—J. H., aged fifty-one, a weaver, employed in the Blind Asylum, was admitted to the Royal Infirmary, June 11, 1880, complaining of weakness and numbness in hands and feet, with pain in the back. He had been ill for twelve days. Family and personal history were unimportant. The patient stated that on June 6th he had, after sleeping for a couple of hours on a sofa, felt on rising that he was chilly, and had a numbness and weakness in both legs and feet, as if they were "sleeping." The following day the symptoms continued, but he managed to work, although feeling the extremities cold and with "pins and needles." During the following day a further increase of discomfort took place, so that on the next he was

unable to go to work. On the 11th he was able to walk from the Blind Asylum to the Infirmary, a distance of about a quarter of a mile, but with considerable difficulty and great uneasiness, and the effort was followed by a feeling of intense fatigue. Some days after the feet had become affected the hands became involved in a precisely similar manner. On admission there was nothing wrong except in connection with the nervous system. Sensory functions: Pain was felt in the small of the back on the slightest movement, but was not severe. He complained of feelings of coldness, formication, and numbness in the feet and tips of the fingers. Sensibility to touch was distinctly impaired in the parts in which the abnormal sensations were localized. The right hand and foot were worse than the left. Sensibility to heat and cold distinctly diminished; to pain, natural. The muscular sense and the special senses were normal. Motor functions: The organic reflexes were natural. The skin reflex absent in right foot, diminished in left. Patellar tendon reflex absent in both legs. Passive motion of all the limbs was normal. Voluntary motion was lost in the toes, very imperfect at the ankles, normal at the knees and hips. The hands, particularly the right, were much weakened. The movements of the wrists, fingers, and thumbs, although feeble, were not lost. The patient could neither walk nor stand unsupported. Co-ordination seemed impaired. He could not write, and had the greatest difficulty in buttoning an easy button. Vaso-motor and nutritive functions: The feet, and to some extent the hands, were cedematous. The muscles of the affected parts were flabby and undergoing atrophy. The cerebral and mental functions were natural, and the spine exhibited no curvature or pain on percussion. He was ordered one drachm of liquid extract of ergot three times a day. During the following fortnight there was a good deal of constipation, and somewhat later a girdle-pain was complained of round the abdomen. In the latter part of July it was occasionally necessary to draw off the urine by catheter.

On Aug. 12th there was some pain round the abdomen and a feeling as of a tight bandage over both feet. The sensibility to touch diminished in the feet. Moderate heat was perceived correctly, but slowly; great heat was perceived instantaneously. Pain of other kinds was felt naturally; special senses natural. Organic reflex functions interfered with in respect of micturition and defæcation, the former apparently by spasm, but less troublesome

than before. Skin reflex of soles diminished. Patellar tendon reflex lost in both legs. Voluntary motion slightly improved in the legs; in the hands now practically restored.

During September improvement went on. Towards the end of it he was able to walk a few steps with the aid of another patient. In the end of October he was able to walk a distance of an eighth of a mile. Since that time he has been steadily improving. During the later stages of the case strychnia was substituted for the ergot which had been used at first.

CASE III.—G. F., aged thirty-one, hotel-keeper, was admitted to the Royal Infirmary, Nov. 8, 1880, complaining of general weakness, pain, stiffness, and loss of power in hands and legs, and confused vision. He was a German by birth, had been employed in various hotels, and had recently become proprietor of an hotel and got married. Early in August he noticed a weakness in the legs and a dancing of objects before his eyes. In September pain came on in the legs. It was of a prickly character, and gradually increased. Towards the end of October a similar feeling came on in the fingers, and afterwards the hands, the feeling being accompanied with loss of power and stiffness, the symptoms also becoming gradually more intense. On admission it was found that there was nothing important wrong except in the nervous system. Sensory functions: He had pain of a tingling character in both legs, from the knee to the dorsum of the foot, with numbness; a feeling of cold in the toes and plantar surfaces; so also in the hands, but to a less extent. There was no girdle-pain, formication, or giddiness. Sensibility to touch was diminished in the legs below the knees, and in the hands. The transmission of impressions was delayed, and he had difficulty in localizing them. Sensibility to heat, tickling, and pain were all diminished. Muscular sense: Normal in the hands, appeared almost absent in right foot, and diminished in left. Sight appeared normal, but he complained of objects dancing before the eyes. There was no nystagmus; the other special senses were normal. Motor functions: Organic reflex functions normal; the skin reflex absent in soles; the cremasteric reflex and that of the trunk well marked; the patellar tendon reflex absent in both legs; voluntary motion was greatly impaired in legs and hands; the fingers remained in a semiflexed position; electric sensibility and irritability much diminished in legs and forearms, specially the extensor muscles; attempt to use the

muscles produced great pain. Vaso-motor and nutritive functions were normal. Cerebral and mental functions were somewhat impaired. He was drowsy, memory imperfect. Although he conversed tolerably well, he made mistakes—such as calling every day Sunday. The cranium and spine were normal.

On the 17th some degree of improvement is reported to have existed, but a few days later the patient was seized with croupous pneumonia of both lungs, of which he died on the 4th of December. On post-mortem examination the spinal cord in the highest cervical and lowest dorsal regions was found to be healthy, but in the cervical enlargement, and to a less extent in the lumbar, there were what appeared to be certain tracts of secondary degeneration. They were extremely sharply defined at the margin, but very faint, and affected only the columns of Goll and the outermost part, particularly towards the back of the lateral column. "The median, ulnar, and tibial nerves showed more notable change than any other part. Looked at with a low power in transverse section, certain bundles of nerve-fibres appeared to be totally destroyed from what looked like fatty degeneration; others were only partially destroyed, while some were comparatively healthy. . . . In the medians there was hardly a sound bundle of fibres.

"Under a higher power, the degeneration presented the following characters: It began by a swelling of the axis cylinder so as to form a number of fusiform bodies in the course of the nerve-tube. These, when they had reached a certain size, divided into a number of rounded bodies varying in size, but mostly considerably larger than a leucocyte. They were perfectly homogeneous and resembled ordinary colloid bodies in every respect. The whole course of the axis cylinder thus underwent degeneration. When the colloid masses were set free they mostly underwent fatty degeneration, forming compound granular corpuscles. In some strands of the fibres the whole of the axis cylinders were destroyed and nothing but a quantity of fibrous tissue remained. Two cords of the brachial plexus were examined. In neither was there any evidence of the disease as seen in the lower nerves of the limb. Most of the bundles of nerve-fibres appeared normal."

In the next case the neuritis followed an injury, though whether it was directly dependent upon it is doubtful.

Roth.—Acute Disseminated Neuritis.*

A workman, aged twenty-five, received two stabs, one on the left shoulder, the other in the abdomen. The two wounds healed well, and on the thirteenth day there was some fever and inflammation of the left parotid. The following day there was paralysis of the left side of the face, which persisted in spite of an incision into a parotid abscess. The general condition was good, when suddenly on the fortieth day the patient was seized with difficulty of swallowing, which became so great that he had to be fed by a tube. After this, step by step, there followed lingual paralysis; then aphonia, then tinglings in all four limbs with motor paresis, were marked in the lower extremities, especially the left. There was loss of patellar reflex, and sensation to touch was diminished. On the sixtieth day the patient died with paralysis of the respiratory muscles. The patient remained sensible until the end; there was never either pain or fever. At the post-mortem the brain, medulla, and the spinal cord were all found to be in a natural condition, but the peripheral nerves showed various lesions. There was fatty degeneration of the myeline with multiplication of the nuclei of the sheath of Schwann, and filling of the sheath of Schwann with cells both round and oval. In addition, the connective tissue between the bundles of nerves was filled with small round cells of connective-tissue origin. Speaking generally, the changes in the nerve-fibres and in the connective tissues coexisted in the different nerve-trunks, but were not always equally well marked. Some nerves, as for instance the hypoglossal, were uniformly affected in their whole length. The morbid process attacked the roots of the nerves. All the sensory nerves were less affected than the motor. Of the cranial nerves, those of the muscles of the eye were the least affected. In the left fifth pair the inferior maxillary was the most affected. The eighth of the cranial pairs on the left side were intact; the seventh contained but few natural fibres and was composed essentially of fusiform cells; the ninth was but slightly diseased, as was also the tenth, but the recurrent laryngeals, especially the left, were considerably diseased; the eleventh and twelfth nerves were very much diseased, especially those on the left side. As regards the spinal nerves, the alteration was most marked in the anterior and posterior roots. In the fine nerve-branches of the great pectoral

* *Rev. des Sci. Méd.* 1884, vol. xxiv. p. 196.

muscles there were some fibres much degenerated. The phrenics were healthy, but their branches in the diaphragm showed considerable alteration. The two cervical sympathetics were scarcely affected, their ganglion cells were normal; there were no cellular proliferations. Some fibres of myeline alone seemed a little friable. The striated muscles were generally well preserved. There was no fatty degeneration and rarely multiplication of nuclei in the muscles corresponding to the degenerative nerves. Much of the fibre of the tongue was in a condition of fatty degeneration. The author is of the opinion that the neuritis resulted from an extension of the inflammation from the inflamed parotid to the neighbouring nerve-trunks.

S. G. Webber.—Multiple Neuritis.*

A man, aged twenty-two, was admitted into the hospital on Dec. 7, 1883. He was well until one year ago. Since then had had pains in the abdomen and back, at times lasting several hours. On Nov. 27th he took cold. On Dec. 2nd had pains in the legs, next day in the arms, with a constant aching of the muscles, worse in the right arm and left leg. Swellings of arms and legs: chilly and feverish. On examination it was found that there was tenderness over the biceps on both sides, over the muscles of the right forearm, and over the left radial nerve—not over the other nerves of the arms. Tenderness also over the calves and the thighs on both sides, over the peroneal nerves and over the sciatics. Both hands and both feet were swollen. No swelling of arms above the wrist: face swollen. Both arms were contracted in a partially flexed position, the left arm being most contracted. All the muscles below the hips were more or less paralysed. Plantar reflex was most marked on the left; patellar reflex was absent on both sides. No ankle clonus. The faradic reaction was not tested until after the patient had been in the hospital for several days; then it was found that the tibialis anticus, peronei, and vastus externus on both sides responded feebly. The rectus femoris and vastus internus did not respond at all. The interossei reacted moderately well; the extensors of the forearm, supinator longus, and biceps reacted scarcely at all. The triceps, deltoid, and flexors responded somewhat better. The facial muscles responded with very nearly the same strength as in health. The patient was

* *Archives of Medicine*, 1884, vol. xii. p. 33.

treated with salicylic acid, iodide of potassium, and electricity. The swelling, pain, contraction, and paralysis gradually yielded, and after about two months and a half he could get about fairly well. The cedema reappeared occasionally: patellar tendon reflex did not return before he was discharged. On April 7th he was again seen. There was no contraction, no tenderness of arms or legs; there was absence of patellar reflex on the left; it was very slight on the right.

S. G. Webber.—Multiple Neuritis.*

A woman, aged twenty-eight, was admitted into hospital on Oct. 26th. Two months ago she took cold during the catamenia, after which she began to have pain in the abdomen. This was followed by numbness and loss of sensation. There was a girdling sensation about the waist, which disappeared later; no pain in the back. The numbness gradually passed downwards, left the abdomen, and, on admission, it was confined to the knees and legs. Occasionally there were sharp pains in the legs, at other times a dead aching. She could move her legs and feet, but the legs were slightly flexed at the knees, and attempts to extend them or to sit up caused a feeling of distress. She was unable to stand: the pain was worse at night. There was general tenderness over the muscles of the legs and thighs, and in the arms near the wrist over the popliteal and sciatic nerves. There was diminution of tactile sensation in the left leg as compared with the right. The plantar reflex was fairly good; patellar tendon reflex was absent on both sides. To the faradic current on the right the tibialis anticus acted fairly well; the peronei, rectus femoris, vastus internus, and gastrocnemius not quite so well. On the left the tibialis anticus acted best. The rectus femoris gave scarcely any reaction; the gastrocnemius also responded very sluggishly. To the galvanic current on the right the tibialis anticus responded readily, and gave a quick contraction to fourteen cells. The peronei gave a slow but strong contraction to twelve cells. The gastrocnemius responded very sluggishly to sixteen cells. Very nearly the same reactions were obtained on the left. The pain and tenderness increased in the legs and extended to the upper extremities, the nails and ends of the fingers being first affected. There was tenderness over all the larger nerve-trunks in both arms. The treat-

* *Archives of Medicine*, 1884, vol. xii. p. 33.

ment was salicylic acid, blisters over tender nerves in the arms, morphia to relieve pain, and compresses of carbolic acid solution over the painful muscles. On Nov. 16th most of the pain had left the legs and fingers. The fingers were anaesthetic, their ends tender on pressure. Pressure on the calves also caused pain. The tenderness had disappeared from over the ulnar and radial nerves, but was still considerable over the median and popliteal on both sides; slight over the left sciatic. Nov. 21st: The pain was entirely gone from the legs and arms, but the legs were still partly flexed. On Jan. 19, 1884, tenderness was quite gone from the fingers, except the forefingers. The grasp of the hands was of moderate strength and the same on both sides; the calves of both legs were still tender, and the peronei did not respond to the faradic current on either side. The gastrocnemius and rectus femoris required strong currents. The vastus internus did not respond on the left and required a strong current on the right. There was contraction of the flexor muscles of the legs, so that the legs were bent at nearly right angles to the thighs. The feet were also in extension, and an effort to rectify the position of either the legs or feet caused considerable pain. By means of massage, and extension by weights, and with the aid of electricity, the vicious positions were rectified. Five months after admission she was able to walk with assistance. The heels did not touch the floor in standing. She could not stand upright. A month later she was able to walk without assistance and helped in the work of the ward.

Caspari.—Multiple Neuritis.*

On the 29th of January the patient was seized with pain in the lumbar region. Three days later he had fever. On the 16th of February, as the fever continued, he was treated with salicylic acid. As a result, the temperature fell to normal. During the seventeen days of fever the patient complained of pains in the lumbar region and in the extremities. The pains extended from the lumbar region to the buttocks, the thighs, thence to the left leg, following exactly the course of the nerve-trunks. The pains disappeared suddenly at night and appeared the following day in the right lower extremity, reappearing in the left, invading the upper extremities, and always following the course of the nerve-

* *Rev. des Sci. Méd.*, 1884, vol. xxiv, p. 195.

trunks. At the end of seventeen days the pain had disappeared, but paresis and trophic troubles remained, especially of the lower extremities and of the left arm.

Leyden.*—A sailor, aged twenty-eight, was admitted into hospital in Feb. 1878. He had had fever, and sharp tearing pains for some days in the arms and legs, apparently proceeding from the knees and elbows. The soft parts below the knees were swollen, white, and very sensitive to pressure. In the fingers and toes was a feeling of formication and numbness. In a few days there was atrophy of the muscles, especially of the extensors of the arms. In the course of some months the legs got quite well, but the arms got worse, and the muscles showed the reaction of degeneration. The patient died of kidney disease a year after the commencement of the symptoms. At the post-mortem examination the spinal cord and the anterior nerve-roots, as well as the nerves of the lower limbs, were found to be in a natural condition. The nerves of the arms were in a condition of sclerotic atrophy.

Pierson.†—*Multiple Neuritis*.

A healthy man was seized with ascending paralysis of the extremities and of the trunk, also with double paralysis of the facial and of the vagus nerves. There was increased frequency of the pulse. The phenomena of paralysis attained their height in eight days, and were accompanied by severe pain, profuse sweating, jaundice, and fever. There was also great diminution of sensibility, and abolition of reflexes, with loss of muscular sense, and electric contractility, as well as progressive muscular atrophy. Later on, vaso-motor troubles, with trophic changes of the skin, supervened. The patient recovered.

From the foregoing cases we may draw up a tolerably accurate description of the course of multiple neuritis, and, taken in conjunction with other cases, the following conclusions appear to be warranted:

The disease attacks males and females in about equal proportions, and occurs at all ages after adult life. In one case, mentioned by Webber, the patient was only nine years old.

* *Zeit. für Klin. Med.*, 1883; quoted by Stewart, *loc. cit.*

† *Revue de Chirurgie*, 1884, p. 233.

In most of the cases no cause can be assigned. In some the illness was attributed to injury, in others to exposure to cold and wet. The earliest symptoms are most usually referred to the periphery, the hands and the feet being the parts first affected. Numbness, with feelings of "pins and needles," usually marks the onset. This numbness gradually spreads, and is succeeded by complete anæsthesia. In many cases the skin is hyperæsthetic in patches. Sensory impulses are sometimes much retarded in transmission, and the power of localization is impaired.

Occasionally pain is severe from the first, and is referred to the nerve-trunks. The latter may be very tender, and are sometimes swollen. Accompanying these early symptoms there is generally a certain amount of fever, but the disease may run its entire course without any rise of temperature.

Various trophic changes often make their appearance early in the disease, and are usually confined to the peripheral parts. Glossy skin, eczema with complete desquamation of the epidermis, bullous eruptions, ulcers, or mere congestion and blueness with loss of temperature, are amongst the most common of such changes. Webber mentions that he has occasionally seen œdema and excessive sweating. Both the sensory and trophic changes are usually symmetrical.

Loss of muscular power is usually described as following upon the sensory and trophic symptoms. At first there is mere paresis, affecting the peripheral parts, and usually symmetrical. To this complete paralysis gradually succeeds and extends to other muscles. Usually the paralysed parts are flaccid and limp; rarely there are contractions.

Reflex actions are gradually lost, patellar reflex being one of the earliest to disappear. The skin reflexes may persist for some time. Loss of muscular coördination is frequent, and is often accompanied by loss of muscular sense. Movements of both the upper and lower extremities may thus become of an ataxic nature. The paralysed muscles usually waste rapidly. Examined electrically, they rarely react normally. Frequently their faradic excitability is either diminished or altogether lost. To the galvanic current there may be marked reaction of degeneration.

The course of the disease varies much in different instances. Very rarely, as in the case recorded by Eichorst, the neuritis spreads with great rapidity and speedily kills the patient. In other instances—*e.g.*, those by Stewart—the symptoms scarcely

PLATE 4.

A hand, showing a peculiar eruption of an eczematous nature
in a case of multiple neuritis following an injury to the back.

Page 482.



extend beyond the hands and feet. In others again—and these the most numerous—the neuritis extends centripetally, fresh skin areas and fresh muscles become implicated, the nerves of the trunk and the cranial nerves may become diseased, and the patient may die after suffering from difficulty in swallowing and in breathing, or from interference with the heart's action. It appears probable from the cases of Stewart and Duménil that in some patients the inflammatory changes extend to the spinal cord itself. But although in most instances the symptoms do extend beyond the hands and feet, yet a fatal termination is by no means so frequent as is recovery. The rapidity with which improvement occurs is very various, and sometimes months may elapse before restoration of function is complete. The order in which the parts recover is the reverse of that in which they are attacked, so that whilst the hands and feet are the first to suffer they are the last to be restored to their natural condition.

Cases of multiple neuritis due to alcohol accord in the main with the description I have just given, but in these there is often much impairment of the cerebral functions, with loss of memory and general enfeeblement of volition. In addition to this, Dr. Buzzard has laid especial stress on the marked paralysis of the extensors of the foot, giving rise to the condition which he has named “dropped foot,” and which in such cases is always present. General tenderness and hyperæsthesia with severe shooting and boring pains in the limbs are usually marked phenomena in cases of alcoholic neuritis.

The diagnosis of multiple neuritis is discussed at length in all recent works on the nervous system, and I do not propose to do more than merely mention it here. It has to be made from the following diseases more particularly :

- (1) Acute ascending paralysis.
- (2) Acute anterior polio-myelitis.
- (3) Tabes dorsalis.
- (4) Chronic spinal meningitis.
- (5) Chronic myelitis resulting from pressure of any kind.

For a more complete discussion of the diagnosis of multiple neuritis I would refer to the lectures by Buzzard as well as to works on diseases of the spinal cord, and for the present will only point out the more salient points.

(1) From acute ascending paralysis the diagnosis is to be made by the numbness and anæsthesia, by the electrical reactions of the

muscles, and by the trophic lesions which are often present, for in the former disease sensation is scarcely, if at all, affected, the muscles react normally, and trophic changes are never noticed.

(2) From acute anterior polio-myelitis the diagnosis may be made by the presence of sensory disturbance and of trophic lesions; by the gradual extension from the periphery; by the frequent implication of all four extremities; by the pain and tenderness over the nerve-trunks.

(3) Some cases of multiple neuritis simulate tabes dorsalis so closely as to have been mistaken for it by the most careful observers. I believe that it is only by watching such a case throughout that the diagnosis can with certainty be made. This difficulty is, however, quite exceptional, and in the great majority of cases attention to the symptoms I have described will leave no doubt as to the diagnosis from tabes. The progress of the latter disease is never so rapid as is that of multiple neuritis.

(4) In spinal meningitis there is usually stiffness of the back, with pain and tenderness on pressure. If numbness or paralysis be present it does not commence at the periphery, and is liable to be very erratic.

(5) In myelitis from pressure, the lower limbs alone are usually affected, and the bladder and rectum are liable to be the seat of paralytic symptoms, with incontinence. The latter symptom is rarely present in neuritis, and never occurs early in the disease.

Treatment of Neuritis.—In undertaking the treatment of a case of neuritis, the first thing is to discover the cause. If there is any history of syphilis, of rheumatism, or of gout, constitutional remedies should be employed which are suited to the disease in question, and there is abundant evidence that they may be given with every hope of success. Thus, mercury and iodide of potassium must be given in syphilitic neuritis; salicylic acid and quinine or alkalies, in rheumatic neuritis; colchicum, diuretics and alkalies, in neuritis due to gout.

In cases of idiopathic neuritis, medicine seems to have but little effect in promoting a cure. Quinine and salicylic acid are, however, recommended by reliable observers. To relieve pain or procure sleep, sedatives of all kinds may be employed. No one appears to be superior to the remainder. Locally, when there is evidence of inflammation of an acute form, leeches appear to be useful. Cooling lotions and belladonna fomentations may be

employed to relieve pain. The limb should be wrapped in cotton-wool and kept at complete rest.

In less acute cases, or when the neuritis has become chronic or is passing away, galvanism or faradism appears to be of great service. The currents employed should at first be weak, and only applied for a short time each day. Later on, stronger currents may be employed. As to which current to use, there is some difference of opinion. I am personally inclined to give preference to galvanism, and so long as improvement continued should not make any change. Where improvement was not apparent I would use the faradic current.

In chronic cases, blisters applied over the course of the affected nerve, with gentle massage and passive movements, may be of use, and should be given a trial. In all cases in which there is a history of chronic alcoholism, all alcoholic liquors should be prohibited, and nervine stimulants, especially strychnia, with ammonia and ether, should be administered. Whether operative measures are ever of any avail is at present doubtful. It is possible that nerve-stretching may be beneficial, though in what cases it should be employed we have yet no guide.

I would, however, recall a case, which I have described at length when treating of the use of nerve-stretching in tabes dorsalis, in which the operation of nerve-stretching was performed with great benefit to a patient who was supposed to be suffering from the latter disease. Nevertheless, on his death from chloroform some months later, the spinal cord was found to be quite healthy, but multiple neuritis was discovered. In another case, recorded by Hillier,* Bardeleben stretched the brachial plexus in a case of multiple neuritis. The operation was followed by considerable improvement in the movements of the hands and fore-arms, but notwithstanding the treatment a fatal result ensued.

I do not myself think that nerve-stretching is likely to do good, and at the best I believe it could only improve local symptoms, and not prevent the tendency to spread, or in some instances to cause death.

* *Rev. des Sci. Méd.*, 1884, vol. xxiv. p. 291.

CHAPTER XXVII.

NEUROMA.

Neuromata.—The term neuroma is usually employed to signify a tumour growing in connection with a nerve-trunk, and it is in this sense that I use the name. Neuromata thus defined may be divided into two main classes—the true and the false. I have already dealt with traumatic neuromata.

A true neuroma is one which is composed of nervous tissue. This tissue may either consist of nerve-fibres, medullated or non-medullated, or else of true ganglionic cells with a surrounding meshwork of fibres. In almost all true neuromas the nerve-tubules are not continuous with those of the nerve-trunk to which they are attached, and, as a rule, are not arranged in any definite order, but form an irregular network mixed with a varying amount of loose connective tissue. The majority of the fibres are smaller than those composing a normal nerve, and often some of them have scarcely any medullary sheath. Although the matrix in which these fibres lie is generally composed of connective tissue, it may consist of myxomatous or sarcomatous elements.

Neuromas composed of nerve-fibres and ganglion cells are extremely rare, so much so that some authorities doubt their very existence. I have, however, seen one for myself in connection with the pituitary body, though I have never met with an example of such a growth on a peripheral nerve. The following cases also appear to be reliable instances.

Dubujadoux and Chevalier.—True Neuroma, containing both Nerve Cells and Fibres, of the Anterior Roots of the Ninth Dorsal Nerves, causing Compression of the Cord.*

The patient was a girl, aged nineteen, who had suffered from gradually increasing paralysis for six months. She became

* *Archives de Physiologie*, 1883, vol. ii. p. 95.

completely paraplegic and died on Oct. 29, 1882. A post-mortem examination showed a tumour compressing the spinal cord opposite to the origin of the ninth dorsal nerves, but only affecting their anterior roots. Microscopically examined, this tumour was found to be a neuroma consisting in part of fibrous tissue and in part of true nerve-tubules with branching nerve cells.

Duplay.—Neuroma, composed partly of Sarcomatous Tissue and partly of Axis Cylinders without Sheath of Schwann.*

The patient was a girl, aged twenty-five, who had noticed for fifteen years a small tumour on the front of the left wrist. For five years it had been painful. An examination of the arm showed that the tumour was situated upon the front of the wrist in the line of the radial artery. It was one centimetre and a half in length and oval in shape. To the touch it was elastic, covered by natural skin and movable upon the deeper parts to a certain extent. It was extremely sensitive, and the patient complained of shooting pain in the hand, and particularly in the thumb, and the tumour was compressed. She also suffered from spasmodic shooting pains of subcutaneous origin situated in the hand, forearm, and arm. On Jan. 16th an operation was performed and the tumour was removed. It was not noticed at the time of operation that it had any connection with a nerve-trunk. Microscopical examination showed that it was composed both of connective-tissue cells and of interlacing filaments of nerve-tubes devoid of any sheath. From the description, however, of the microscopic characteristics, I think it is doubtful whether what are described as nerve-tubules really were such.

Duhring.†—Case of painful Neuroma of the Skin, composed of Non-medullated Nerve Fibres.—Resection and Union of Brachial Plexus.

“An Irishman, aged seventy, ten years ago first noticed a few small round nodules in the skin of the left shoulder, attended by decided itching, but without pain. These nodules soon multiplied and increased in size. For four years they continued to appear in numbers, and by this time the arms and shoulders were studded by them. For five years past their increase in number has been

* *Archives Générales de Médecine*, 1878, vol. i. p. 405.

† *American Journal of Medical Science*, vol. lxxiii. p. 413; and vol. lxxxi. p. 435.

slower, but new ones have continued to appear up to the present time. Some of the older ones have increased in size. There was no pain until three years after the first eruption. At the present time the disease is characterized by numerous, small, rounded, hard nodules, occupying the left scapular region of the shoulder and outer surface of the arm as far down as the elbow. They are incorporated with the subcutaneous tissue, varying in size from that of a pin's-head to that of a large pea, and at certain points are situated close together. They are elevated from one to four or five lines above the level of the surrounding skin, and present a marked tubercular, knotty appearance. They are firmly seated in the skin, and are in no instance pediculated. Over the shoulder and arm, at the insertion of the deltoid muscle, the tubercles are closely packed together, and the intervening skin, although not tuberculated, is involved in the same new growth. The tubercles are scattered in irregular form and without definite arrangement. They do not keep to any particular nerve-tract. The affected side of the body, including the arm, corresponds in size with the healthy side. The diseased skin varies in colour according to the locality where the affection is most marked. About the shoulder the tubercles are a purplish pink colour, with a mottled appearance. Where they are isolated their colour is pink and still lighter in shade, but the whole surface is liable to great variation in colour. The tubercles are here and there covered with fine yellowish-white scales, which give to some of the older tubercles a whitish glistening appearance. There are no tubercles on the under surface of the arm from the axilla down to the elbow; here the skin is normal in every respect. The tubercular mass about the shoulder and arm is warmer to the touch than the other portion of the arm. The original starting-point of the affection appears to have been at or about the insertion of the deltoid muscle, for here the tubercles are thickest and the pain most severe. During a paroxysm of pain the tubercles and skin involved change colour rapidly, passing through various shades until they become purplish and even livid at times. As the paroxysm is ushered in, and when it is at its height, the parts are seized with a quiver, which extends over the whole of the arm, and is paroxysmal, occurring for a few seconds only during the height of the attack. Intense pain of a paroxysmal nature constituted the distressing feature of the disease. This developed gradually, first showing itself about three years after the appear-

ance of any external manifestation, and soon increased in severity, keeping pace with the development of the disease. The pain during a paroxysm is excruciatingly severe, and from my repeated observation I doubt if any words can express the amount or character of the suffering the patient undergoes. As the pain comes on he endeavours to support the affected arm with the other hand, pressing it towards the body, but he dare scarcely touch it, for so sensitive is it that even the breath blown upon the surface excites additional pain. At one time he endures the paroxysm in a standing position, or he seats himself upon a chair or the floor, and remains in a cramped condition until the extreme pain ceases. The very intense suffering remains at its height but for a short time—from ten minutes to half an hour—when signs of abatement are noticed, and in an hour or two the attack subsides. The paroxysms vary in duration and in frequency of occurrence; they also vary in intensity according to the immediate cause which has occasioned them. When slight, the attack lasts perhaps ten minutes, or, if severe, an hour. If quiet and undisturbed, and with the part protected, there may be but one or two paroxysms in the course of the day; but if the patient becomes worried or excited from any cause, the attacks are much more frequent and correspondingly violent. Exposure to cold invariably causes pain. It is influenced much by the change of the weather. He is always worse and suffers more during a rainy or snowy season. He is decidedly better in summer than in winter. Before entering the Philadelphia Hospital he submitted to have the arm and shoulder thoroughly blistered, which proceeding he thinks gave him some relief for a period of six weeks. Since then he has been treated in varying ways, but without any alleviation. With the hope of ascertaining the nature of the disease the man consented to the excision of several of the tubercles. Three were selected in different regions as being most characteristic, and were removed. Severe pain followed the operation. The wounds were closed and cicatrized. The nodules directly after removal were of the size of large peas. Cutting one of them open vertically, the inner surface presented a dull white colour affording scarcely any blood or fluid upon pressure. The cut surface appeared homogeneous and solid throughout to the naked eye. The growths were not found to possess any filamentous attachment. Microscopically examined, the epidermis was irregular and uneven in structure, and here and there completely

broken down. The rete was imperfectly developed in certain sections, at one point showing normal growth and arrangement, while in other sections there seemed to be an abnormal development of the younger cells. A singularly eccentric formation of the rete was here and there noticed, resembling the globular arrangement of epithelioma, but this condition was not universal. The papulous layer was irregularly developed. The papulae were here and there greatly hypertrophied. The corium was abnormally inflated with new tissue growth, which was firm in structure. The tissues beneath and the mass of the specimens consisted of solid connective tissue irregularly developed and uneven in arrangement. The bulk of the tissue was old in appearance; the connective-tissue fibres were closely packed, in places forming wave-like bands. There were also numerous free fibrils of elastic tissue scattered here and there through the specimens, but among the many sections examined it was impossible to find either nerve-trunks or branches. In Feb. 1874 a portion of the brachial plexus of nerves was excised by Dr. Mauray for the relief of the excruciating pain which the patient suffered, and which was thereby greatly relieved. Within a year, however, the pain became more violent, and two years later existed as severely as before the operation. Up to the time of death no marked change occurred. The patient died on Feb. 16, 1880, six and a half years after the operation, and having been under my observation thirteen years. The paralysis and general atrophy and wasting of the limb remained unchanged, and death appeared to be due to old age, the patient being in his eighty-third year. A careful examination after death showed that the brachial plexus of nerves had united, a large whitish mass of firm tissue one and half inches in length, half an inch in thickness, and one-eighth of an inch in width, constituted the connecting point between the divided ends of the nerves. The fifth and sixth nerves entered the mass as one trunk, the seventh alone and on the upper surface. The lower two nerves united to form a common trunk before entering the scar. Microscopically examined, the mass was found to be made up of various interlacing bands of fibrous tissue, in which were contained numerous bundles of nerve-fibres surrounded by their connective-tissue investments. Many of the bundles are composed of well-formed medullated nerve-fibres. In some places, instead of a number of nerve-bundles a single fibril was seen, surrounded by masses of connective tissue. In other portions of the section the nerve-fibres are not well formed.

Portions of the existing tubercles examined microscopically showed a connective-tissue stroma interwoven with the elements of the new formation, which consist of non-medullated nerve-fibres of various lengths and directions, but for the most part lying parallel with one another, each fibre being composed of a finely granular central substance, surrounded by a sheath containing numerous elongated, oval, somewhat granular nuclei—in other words, it exhibits the character of non-medullated nerves and the components of a ‘true neuroma.’ In addition, there may be seen yellowish elastic tissue; blood-vessels with thickened walls, which contain numerous nuclei; and, finally, surrounding each vessel, a small collection of round, lymphoid, cell-like bodies resembling in character the nuclei in the walls of blood-vessels. The microscopic studies were made by myself originally, and later by Drs. Formad and De Schweinitz.”

A false neuroma is a tumour situated on or in a nerve, but not itself containing any nerve elements. There are several varieties of false neuroma, but the most common of such tumours are fibromata of the “hard” variety, and consisting almost entirely of white fibrous tissue with but few connective-tissue cells.

The tumours next in order of frequency are sarcomata. They may belong to the round, oval, or spindle-celled varieties. In such growths, especially in those which increase most rapidly in size, degeneration cysts may form, so that the tumour may become partly filled with fluid. The contents of such cysts are usually blood and broken-down cells.

More rarely still, myxomas and gliomas are found growing upon the nerve-trunks, whilst in St. George’s Hospital Museum (Series VIII., Nos. 152 and 153) are two specimens of simple cysts containing clear fluid, one of which was in connection with the median nerve. The following is one of the few recorded cases of myxomas growing on nerves:

Brissaud and Reclus.—Myroma of the Ulnar Nerve.—Removal.*

The patient was a man, aged fifty-three, strong and healthy, who had had a swelling in his arm since his early youth. Six months before coming under notice he received a blow upon the arm; since that time the tumour rapidly increased in size. This

* *Bulletin de la Société Anatomique*, 1881, vol. vi. p. 456.

increase in size was followed by atrophy of the interosseous muscles, with loss of power in the hand and excessive pain in the distribution of the ulnar nerve. An operation was undertaken for the removal of the tumour, which was situated chiefly behind the nerve. After removal, it was found that the new growth was of the nature of a myxoma, and in its centre there was a cavity containing a little bloody fluid.

Another case of myxoma is recorded by Dr. Sharkey, in his *Gulstonian Lectures*,* the tumour growing on one of the cervical nerves within the spinal canal, and causing death by compressing the spinal cord.

There has recently been added to the museum of St. Bartholomew's Hospital a very unusual specimen of a cyst in connection with the ulnar nerve. The hand was removed by Mr. F. S. Edwards from a dissecting-room subject, of whom no history could be obtained.

On the anterior branch of the ulnar nerve is an oval cyst, the fluid of which is apparently contained within the nerve-sheath, and is clear and translucent. The cyst may be traced along the deep branch of the ulnar nerve as far as the carpal bones, and in this situation it appears to communicate with the carpal joints. The nerve-fibres are much flattened and separated. It is evident that such a swelling might be the cause of severe symptoms, and it is interesting to note that on the posterior interosseous nerve of the other forearm a similar but smaller cyst was found. The accompanying drawing gives a very good idea of the first of these cysts.

The most common situations of neuromata are the nerve-trunks of the extremities. They may be met with, however, on any nerve in the body.

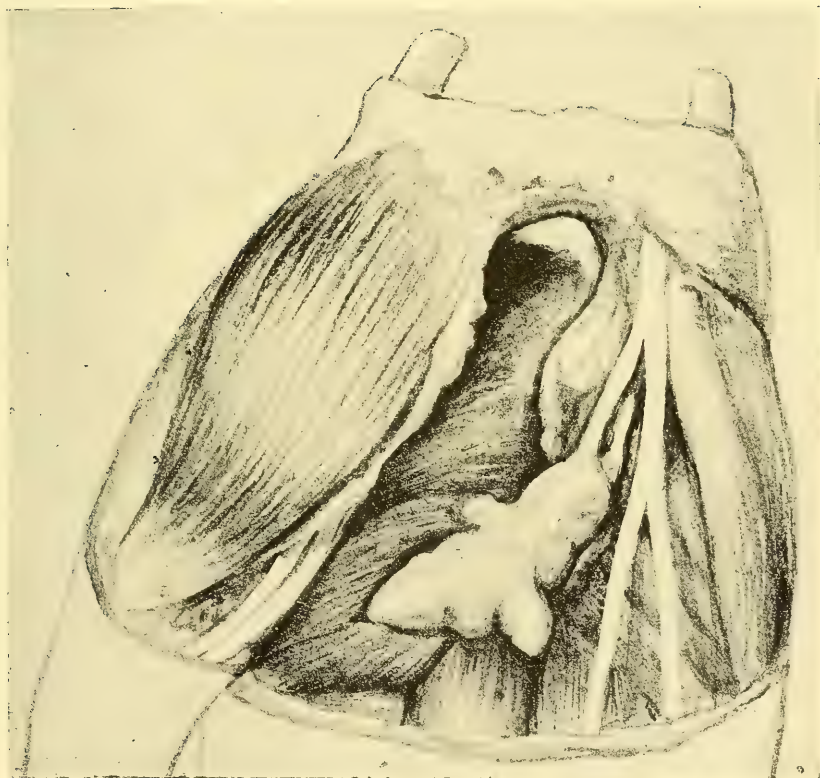
In size they vary from a pin's-head to a hen's egg, but are most commonly about as large as a hazel-nut. In shape they are usually rounded or oval, and with a smooth even surface. Their consistency is variable—the fibromata feeling hard and dense; the sarcomata and the myxomata offering varying degrees of softness, elasticity, or even fluctuation.

Neuromas generally, and more especially those composed of fibrous tissue, lie between the nerve-bundles, pressing them aside, and not actually involving them in their growth. In other cases,

* *Lancet*, April 3, 1886.

FIG. 20.

Part of a hand, showing a cyst on the deep branch of the ulnar nerve in the palm of the hand.



one or more of the nerve-bundles may pass completely through the tumour.

Neuromata are generally single, but occasionally occur in great numbers. Even when numerous they may be confined to a single nerve, or may pervade almost every nerve-trunk in the body.

In the museum of the Middlesex Hospital is a very good example of the former variety, there being many tumours on the posterior tibial nerve, but none in any other parts of the body. The specimen is thus described :

“ Multiple Fibromas on a Single Nerve. ”*

“ A posterior tibial nerve, with the neurilemma in parts removed, presenting a number of globular enlargements on its fibrillæ varying in size from a hen’s egg to a hazel-nut, and also others which form merely a circumscribed thickening of the fibrils. One of the tumours contains a cyst. The larger tumours when recent were of a tough elastic consistence, pale red in colour, and the nervous elements of the fibrillæ were obliterated. The small tumours were seen microscopically to consist of a growth within the membrane surrounding the nerve-tubules, and of corpuscles of irregular shape, though chiefly rounded, without nuclei, and of a yellow colour. (From a dissecting-room subject.) ”

The diagnosis of neuromata depends partly on the symptoms induced by their presence and partly on the physical characters they present when examined. The symptoms vary much in different cases ; and although the following description is true of typical cases, yet it must be remembered that in others no particular symptoms may be noticed.

The attention of the patient is first called to the tumour by pain, which varies in character in different instances. It is felt both at the seat of the growth and in the parts to which the affected nerve is distributed. It is often continuous, but is liable to sudden exacerbations. It is sometimes of a dull, aching, numbing character, but more often sharp, shooting, and of a neuralgic nature. As in true neuralgia so in neuroma, the pain often radiates beyond the affected trunk, so that other neuromas may be suspected where none such are present. In addition to pain, the pressure on the nerve-trunk gives rise to various paræsthesiæ, and the patient complains of numbness, “ pins and

* *Middlesex Hospital Museum Catalogue*, No. 884.

needles," tingling, and formication in the parts to which the nerve is distributed. Where the sensory fibres are completely compressed or crushed by the growth, absolute anæsthesia may ensue, but is very rarely met with.

Muscular movements of a twitching character, and occasionally choreic or epileptiform convulsions, may result from irritation of motor fibres, whilst the complete compression of the same would be indicated by paralysis of the muscles supplied by them. The interference by the growth with the trophic fibres in rare instances results in the production of various trophic changes. The chief of these are a smooth, glossy appearance of the skin, striation and brittleness of the nails, ulceration of peripheral parts, painless whitlows, loss of hair, increase or diminution of sweat, and wasting of muscles.

On clinical examination, a neuroma will be found to present itself as a smooth, oval, or rounded swelling, varying in size as before mentioned, and situated in the course of a nerve-trunk. It can readily be moved in a lateral direction, but is scarcely, if at all, movable in the long axis of the nerve on which it is placed. Pressure on the tumour causes pain, both at the seat of the swelling and also in the parts supplied by the diseased nerve; the latter point is important. The pain caused by the presence of the neuroma may be allayed by pressure exercised upon the nerve-trunk between it and the spinal cord.

The question of the intimate structure of any given neuroma will depend chiefly on the rapidity of its growth and its softness. In proportion as its growth is rapid and its consistence soft, the probability of its sarcomatous nature is increased.

Treatment of Neuromata.—There is but one effectual treatment for neuromata, and that is removal by the knife. The incision should be made in the long axis of the affected nerve, and the tumour carefully enucleated with as little injury as possible to the adjacent nerve-bundles, for it should be remembered that in many cases the neuroma may be removed without dividing the nerve-trunk in any part.

In all cases in which excision of a portion of the diseased nerve becomes necessary, it should first be forcibly stretched to a sufficient extent to allow of immediate suture of the cut ends. For, if the nerve has been resected without this precaution being taken, it may be difficult or impossible to bring the cut surfaces into apposition. In cases where so large a portion of nerve has

been excised as to render apposition impossible, the chances of union are rendered much more uncertain, though no case must be regarded as hopeless in this respect, and the cut ends should always be fixed by suture as near to one another as is possible, or the operation of nerve-grafting, mentioned in a previous chapter, should be performed.

Plexiform Neuromata.—It has not been shown that tumours of this nature actually grow in connection with nerve-trunks, yet, inasmuch as they consist in part of nerve-fibres, I have thought it advisable to give a brief account of them.

The tumours to which this name has been applied consist in part of soft connective tissue and fat, imbedded in which are medullated nerve-fibres and white fibrous tissue. A tumour of this nature was first described by the American surgeon, Mott, in 1854, under the name of "pachydermatocoele." In 1857 Depaul showed a similar specimen at the Anatomical Society of Paris, and since that date other instances have been recorded by Gersant, Billroth, Czerney, and Labbé.

The usual situations for such growths are the forehead, the eyelid, the temporal region, and the neck. They always occur in early life and are not improbably congenital. It is possible that they may be somewhat of the nature of the other congenital tumours which are frequently met with in the temporal regions and are due to inclusion of epiblastic tissues enclosing varying amounts of meso-blast. The growth of the plexiform neuromata seems to be slow. In one case, that of Labbé, the tumour recurred after removal. The following cases by Billroth are good examples of this form of growth :

Billroth.—Neuro-fibroma or Plexiform Neuroma.*

The patient was a student, aged eighteen, who had in the left temporal region a diffused swelling which did not project in globular form, but gave an appearance of widening to the temple and caused the face to look awry. The swelling extended into the upper eyelid, perhaps also into the orbit, and was uniformly soft, save where some hard cords and nodules could be felt. Probably the tumour was of congenital origin. It had increased during the last few years so much that the left eye was closed, and he could not obtain a situation by reason of the disfigurement. A more

* *Clinical Surgery*, p. 94.

minute examination of the face and head showed as follows:—The zygomatic arch on the left side was considerably broader and thicker than on the right; the outer part of the left orbit and anterior half of the left side of the skull were also widened. In the left parietal bone, close to the sagittal suture, an opening the size of a bean could be felt in which the pulsation of the arteries of the brain was distinct. An operation was undertaken for the removal of the tumour, which proved to be very difficult, partly owing to the situation of the growth and partly to its ill-defined extent. The patient made a good recovery. An examination of the tumour showed that it consisted of tortuous bands of fibres of a white colour marked like intestine. The diameter of these fibres, which were with difficulty disentangled, varied from one-half to two lines. In section they were seen to be of a pale grey colour and arranged in distinct layers. Most of the bands were marked with a central faint yellow dot. Under the microscope these bands were seen to consist of cellular tissue rich in cells. The centre showed here and there fat detritus. In the finer bands double contoured nerve-fibres could distinctly be recognized imbedded in and loosely connected to cellular tissue containing a quantity of fat.

Billroth.—Neuro-fibroma or Plexiform Neuroma.*

The patient was a girl, aged fifteen. From an early age it had been observed that the right temporal region was much thicker than the left. The swelling had increased very slowly since its commencement. When the patient was admitted the right temporal region, the outer part of the right upper eyelid, and the upper part of the right cheek were somewhat swollen. The skin of the part was normal in appearance and the swelling painless. The right eyeball was natural. The swollen part felt like a fibroma molluscum, and several hard nodules existed which were tender on pressure. The growth was removed and the disfigurement completely remedied. The tumour was composed of medullated nerves and fibrous tissue imbedded in a soft lobulated fatty tissue.

Multiple Neuromata.—Not only may many neuromata be situated upon any one nerve, but many or all of the nerves in the body may be the seat of new growths. Such cases are certainly rare, and I believe that the total number of recorded instances

* *Clinical Surgery*, p. 95.

only amounts to forty-seven, and the whole of them, with a few exceptions, have been collected by Prudden in an admirable summary of this subject in the *American Journal of Medical Science*, vol. lxxx. p. 134. The first of these cases was published by Monteggia in 1813, and from that date till 1843 only six other instances were recorded. The majority have occurred on the Continent.

The following abstracts of a few cases, taken from Prudden's monograph, will give a better idea of their nature than any description :

Nélaton.—"M. Houels,* in the year 1853, described the following case, which was treated in Nélaton's *clinic*:—Adrien B., aged twenty-six, shoemaker, admitted March 27, 1851, for operation on a tumour in the right groin. Five months before entrance to the hospital he noticed for the first time a swelling as large as a pigeon's egg in this region. It caused him slight pain, especially during changes in the weather. Several tumours as large as a grain of wheat were found in the abdominal walls, others in various parts of the body. Most of them gave him no spontaneous pain, and but slight pain on pressure. They were not adherent to the skin. His general condition was good, though he was somewhat emaciated. Certain muscles, especially those of the forearm, were slightly contracted. General sensibility intact. On April 1st the tumour in the groin was removed, the healing of the wound was slow, not being completed until July, and during this time the other tumours were observed to increase in size. The muscular contraction now became more pronounced; patient complained of pain especially on changes in the weather. He became still more emaciated; appetite good, respiration normal. Contraction of muscles increased, and movements became slow and embarrassed. General sensibility intact, or seemed even to be a little exaggerated. Toward the end of September the patient took finally to bed; the pains became more acute, and did not seem to be localized in the tumours themselves, but were most marked in the forearms and knees. The legs became flexed on the thighs, and finally flexion of the thighs on the body occurred. Passive movements of the legs were still possible, but acutely painful. Later, movements in the upper extremities became impossible, and pressure on the tumours extremely painful; general sensi-

* Houels, *Mémoire sur les Nevromes*: *Mém. de la Soc. de Chirurgie de Paris*, t. iii. p. 53.

bility was still preserved. The number of tumours had now considerably increased. Opium by the mouth and subcutaneously relieved his pain at first, but toward the end was of little avail. In the last days appetite almost completely failed, diarrhoea came on, respiration became embarrassed, pain more and more acute, slight degree of opisthotonos. Still the general sensibility, and also taste, hearing, and smell, remained intact. A bedsore formed over the sacrum; spontaneous luxation at the left hip-joint occurred. Death on Dec. 16th. Autopsy: Brain and cord normal, also the viscera. The cranial nerves within the skull voluminous. On the cauda equina numerous small tumours (the largest of the size of a pea) were found along the nerves; on one trunk twenty were counted. With the exception of the olfactory and optic, all the cranial nerves presented tumours of various sizes. The ophthalmic and Gasserian ganglia were very voluminous. Both pneumogastrics above the stomach presented numerous tumours, but on arriving at this point became normal. All the nerves of the upper extremities were notably hypertrophied, and, with the exception of those in the palmar regions, were beset with tumours; one of these on the median, and another on the radial, were as large as a hen's egg. The lumbar and sacral plexuses were greatly hypertrophied, and presented numerous tumours, as did the smaller nerves of the leg, with the exception of those in the foot. There was a general hypertrophy of the main trunks of the sympathetic in their cervical and thoracic portions, but no circumscribed swellings; in the abdominal portion they were nearly normal. The great splanchnic was voluminous, and presented small circumscribed swellings. Semilunar ganglion and its plexuses normal. Mesenteric plexus presents a few small tumours, the largest of the size of a hazel-nut. Structure of the tumours fibromatous."

Sibley.—Another extremely interesting case is that of Sibley.* Patient, aged forty-five, coach-painter. Had always enjoyed good health until seven years before death, when he began to feel himself growing feeble, but he had no more definite symptoms until four years before death, when the use of the lower extremities became impaired, and by degrees he lost all power of movement. A sloughing sore appeared on the back, and when admitted to the Middlesex Hospital he had no power of movement in the muscles

* *Med.-Chir. Transactions*, 1866, vol. xlix. p. 39.

of the lower half of the body, and the legs were drawn up to the abdomen; they could be drawn down, but would again soon become flexed. He retained some power of movement in the upper extremities, being able to feed himself if the food was cut for him. Cutaneous sensibility was entirely lost in the lower extremities, but a certain amount of sensibility remained in the hands. Urine and fæces passed involuntarily. A large tumour was evident near the left elbow, and another below Poupart's ligament of the left side. Appetite good. There was at first some improvement in the sloughing sore on the back, but it soon became worse, and the patient died one month after admission. Autopsy: Body well nourished. No lesions of thoracic or abdominal viscera. Brain and cranial nerves normal. In the spinal canal numerous tumours were found within the membranes connected with the roots of the nerves, being most abundant in the cervical and lumbar regions. In the cervical region several tumours were found, the largest having the size of a large walnut, and pressing on the cord constricted and softened it. The large tumour noticed during life near Poupart's ligament was attached to the anterior crural, and contained several cysts. The tumours were fibromata.

Generisch.—"Generisch,* in 1870, gave an admirable account of a most interesting case:—Karl P., aged twenty-two, shoemaker. His mother died of carcinoma mammae. She had numerous tumours in the axilla along the ribs, in the precordial region and in the muscles. (These, at the time of her death, were supposed to be enlarged or cancerous lymph-glands; but in view of the history of her sons, and their situation, it is not improbable that at least a part of them were neuromata.) Patient had never previously had a severe illness. Early in 1868, after exposure to severe cold, he began to experience acute pain in the ball of the left foot, which was renewed at every change of the weather. This pain finally became so acute that he sought admittance to the hospital. He was of medium size, looked like a malarial patient, lips pale and bluish, conjunctivæ and mucous membrane of mouth singularly colourless. He had epispadias, and his voice was like that of a child. Numerous larger and smaller resistant fusiform tumours were found scattered over the entire surface of the body, the skin over them being normal. Some of

* Virchow's *Archiv*, Band xlix. p. 15.

them were spontaneously painful; others, of the size of a hazel-nut or larger, also lying deeper, were either not at all painful on pressure or only when considerable force was used. He said that he first noticed them when eight years old. They gradually enlarged and increased in number, some of them being as large as a pigeon's egg. An examination of the blood revealed an increase in the relative number of white blood-cells. But neither the higher senses, nor the sense of touch, nor perception of heat, nor muscular power, were in the least degree impaired. Respiration and heart functions normal. About ten weeks before death he began to have intense pressing, stretching pain in the right buttock, which increased in severity. A rapidly growing tumour was discovered here, which at the time of death had a diameter of 3.5 cm. In the meantime he began to have pain in the right foot, and presently took to his bed. The right foot and leg now became slightly anæsthetic, and assumed a position resembling talipes equinus, and extensive œdema occurred, extending up to the middle of the thigh. Temperature ranged from 38.5 to 39.7 C.; pulse frequent and soft. A persistent diarrhœa now set in. A very painful digital examination of the rectum showed that the gut was pressed upon by a firm rough tumour within the pelvis on the right side. Later, micturition became difficult; urine scanty, cloudy, with reddish sediment, and on several occasions contained albumen. The painful and sometimes bloody diarrhœa was not controlled permanently by the most powerful remedies. A bedsore formed over the right trochanter. During the last days he several times experienced a sensation of coldness, but had no pronounced chill. He died suddenly of pneumothorax. Autopsy: In the lungs were scattered areas of broncho-pneumonia, and small cavities connected with the smaller enlarged bronchi, through the walls of one of which the perforation had occurred. On the surface of both lungs numerous wedge-shaped, soft, whitish nodules were seen as large as a hazel-nut, with the broad end outward. Plugs were found in some of the smaller arteries in the lung tissue. A few scattered neuromata were found along the bronchi. Brain and cranial nerves within the skull normal. The roots of the ciliary ganglion and the ganglion itself were thickened and unusually resistant. Small tumours were found on the oculo-motorius, right trochlearis, and on several branches of the trigeminus. The spinal cord was normal, but the spinal nerves outside the dura

were much enlarged as they passed through the greatly widened intervertebral foramina, the change being most marked in the cervical and lumbar regions. The whole spinal canal was enlarged, especially in the lower lumbar and sacral regions, having in the latter portion a diameter of more than 3.5 cm. Tumours of varying size were found in all the spinal nerves. The phrenics were beset with tumours of the size of a barleycorn. Both vagi were considerably enlarged and knobbed, and in some parts of the thoracic portion measured 9.12 mm. in diameter; upon and below the diaphragm were numerous tumours as large as a pea. Tumours were also found in the various plexuses. The sympathetic nerves were thickened and the ganglia enlarged. Both splanchnics and the intercostals presented tumours, those of the latter nerve projecting through between the ribs into the pleural cavity. Several tumours were found in the subserosa of the stomach, in the porta hepatis, and were very abundantly distributed in the mesentery, the largest having the size of a pea. The true pelvis was filled with large subserous tumours, and such also were found in both iliac fossæ. Tumours of the size of a hen's egg were situated on the branches of the lumbar plexus, some of them containing cheesy masses, others completely calcified. The sciatics were enormously enlarged. The microscopical examination showed the tumours to be essentially fibromata, but some were distinctly sarcomatous, others myxomatous. The wedge-shaped masses in the lungs were sarcomatous, and the author regards them as metastatic. The above-mentioned plugs in the smaller arteries of the lungs consisted chiefly of spindle-shaped cells, somewhat resembling those composing the wedge-shaped nodules. The nerve-fibres could be readily seen passing through the tumours, and the author concluded after carefully counting the nerve-fibres in transverse section before entering and within the tumours that their number was not increased."

Bruns.—"The following case was described by *Bruns*,* in 1870:—P. M., male, thirty-three years of age; general health good. He was born with a flat tumour on the left temple and left upper eyelid, which grew with the growth of the body. It was lobulated, irregularly nodulated, hanging in sack-like folds down to the ear, covering the eye, which was atrophied. Knobby cords

* *Virchow's Archiv*, vol. i. p. 108.

were felt within the tumour, which has given him no special inconvenience. Six years ago he first noticed a tumour on the left side of the neck, which was then about as large as a hen's egg, and lay just below the angle of the jaw. It continued to increase in size, and he came for operation. It was now about as large as the double fist, reached from the jaw to the clavicle and forward to the median line, displacing the larynx. It was freely movable sideways, but not up and down. The skin over it was normal. At first he had for a time no subjective symptoms, but two years before admission he began to suffer from a gradually increasing hoarseness, which, however, never reached aphonia. During the last six months he had darting pains in the tumour, radiating to the ear and back of the head, as well as difficulty of breathing, which was accompanied by a whistling sound, especially after exercise. Vigorous movement of the tumour, or strong pressure on it, induced cough. On various other parts of the body hard tumours were found from the size of a barleycorn to that of a walnut, of whose existence he was unaware. An operation was performed for the removal of the tumour in the neck. On cutting down upon it a nerve was seen to enter it from below, which proved to be the pneumogastric, and was severed. During the operation violent cough and intense suffocatory symptoms occurred, passing off after the manipulations ceased, when the breathing became normal. The patient did well until the tenth day after the operation, when a profuse hæmorrhage occurred, terminating in death. Autopsy: The hæmorrhage was occasioned by an ulceration through the wall of the carotid. The left vagus was beset with fusiform and spheroidal tumours from the size of a millet-seed to that of a bean, down to its finest visible ramifications. On the right vagus tumours were found as large as a walnut. Tumours were also discovered on numerous other nerves, especially on the brachial plexus, the subcutaneous nerves, and on the sciatics and their branches. Some of these were as large as a pigeon's egg.

“A brother of the above patient had a congenital elephantiasis, with plexiform neuroma of about the same size and shape, and in the same region; and his mother had numerous wart-like tumours in the skin.”

Satterthwaite.—Multiple Neuromata.*

At a meeting of the New York Pathological Society the author related a case in which there were multiple tumours of the cranial, spinal, and sympathetic nerves, with remarkably few symptoms. The patient was aged twenty-five. At the age of thirteen she had paraplegia, after an attack of small-pox. She regained motion to some extent under the use of the electric current, and subsequently had severe pain along the course of the sciatic nerve.

On Oct. 14, 1879, she came under notice. Sensation was diminished in the right foot, and motion was limited. After treatment by electricity, she was able to walk in ten days with greater ease, but had dull pains at night.

Nov. 1st: Nausea, vomiting, and diarrhoea set in, and she died on the 4th. Post-mortem examination: There was found to be a large tumour in the right iliac fossa, embracing and including the cords of the lumbar and sacral plexuses, forming a mass as large as a hand, closely connected with the bone. The growths constituting the tumour varied in size from a pea to a goose's egg. They were either on the side of the nerve-cords or pressing upon them centrally. No tumours were found on the spinal cord. The intercostal nerves were beset with tumours up to the size of a small almond, some of which passed through the intercostal foramina. Small tumours were found on the branches of the fifth nerve, and on the occipital, spinal-accessory, and phrenic nerves. The right pneumogastric was beset with tumours, the largest of which measured 1 inch by $1\frac{1}{2}$ inch. The cardiac and œsophageal plexuses presented numerous small tumours, and the cervical portion of the right sympathetic was converted into a bulbous cord, about as large as the little finger. The remaining spinal nerves of the extremities were for the most part thickened. In the foot and hand the change was but slight. Both sciatics as they entered the thighs presented themselves as large knotted cords. In the left leg all the branches of the sciatic, down to the ankle, were beset with tumours, as was the anterior crural with its branches. On the left anterior crural and its branches, 276 tumours, large and small, were counted. In the left arm, all the nerves down to the wrist were thickened, and, especially above

* *British Medical Journal*, 1880, vol. i. p. 485.

the elbow, beset with tumours. They were abundant alike in the muscular and in the cutaneous nerves.

(The microscopic structure of these tumours is not mentioned.)

In most of the cases of multiple neuromata, the tumours have been fibrous, in some they have been sarcomatous, and in a few there have been found cysts—probably degeneration cysts—within the solid tissue of the new growth. In no case have the tumours become disseminated in other tissues, nor have they caused glandular infection. Dr. J. F. Payne, however, has recorded two cases* in which the neuromata coexisted with molluscum fibrosum, and refers also to similar observations by other authors.

Not infrequently more than one member of the same family have been the subjects of multiple neuromata, and several of the patients have been idiots or cretins. Most of the sufferers have been young adults, but the tumours have been met with at almost all ages after puberty.

No particular nerves are affected more than others, as far as the cerebro-spinal system is concerned, but the sympathetics frequently escape. The number of tumours met with in some cases is enormous; thus, in one of Smith's, of Dublin, more than 2000 were counted.

The symptoms caused by multiple neuromata vary greatly. Occasionally but few symptoms are present. In other instances all the pain, impairment of muscular power, and trophic lesions I have already described as occurring in single neuromas, may be present in an exaggerated degree. Many of the patients have lost their lives through implication of the pneumogastrics or of some other cranial nerve, and in a very large percentage of the whole number of recorded cases a fatal result has ensued.

No treatment can be adopted with any hope of success, for it is manifestly impossible to attempt the removal of hundreds of tumours, many of which are situated in inaccessible regions.

* *Trans. of Path. Soc. of London*, vol. xxxviii. p. 63; and *Lancet*, vol. i. 1889, p. 532.

INDEX.

- ABERNETHY, wounds of superficial nerves, 118
 Afferent nerves, 4
 Alcoholic neuritis, 467
 Amputations, changes in nerves after, 27
 Anatomy of nerves, 1
 Anastomoses of nerves, 72
 Anæsthesia after nerve section, 63
 treatment of, 318
 Ashurst, nerve-stretching for traumatic neuralgia, 397
 Athetosis, nerve-stretching for, 374

 BAKER, cases of nerve suture, 138, 141, 143, 150, 188
 nerve injury complicating dislocation, 264
 Balfour, on development of nerves, 2
 Ballance, on nerve-stretching for wry-neck, 387
 Bakowiecki, on regeneration of nerves, 24
 Banks, rupture of brachial plexus, 100
 Baudens, on retained sensation after nerve section, 66
 Baum, nerve-stretching for facial spasm, 381
 Benecke, on degeneration of nerves, 17
 on regeneration of nerves, 23
 Benedikt, nerve-stretching for facial spasm, 384
 Berger, death from nerve-stretching, 353
 Bernhardt, nerve-stretching for facial spasm, 381, 382, 384
 Bidder, nerve injuries complicating fractures, 243
 Bidon, on reflex paralysis, 289
 Billroth, ligature of carotid for neuralgia, 439
 neurectomy for facial neuralgia, 407, 408, 409
 plexiform neuroma, 495
 Blum, arthritic lesion after nerve section, 52
 on reflex paralysis, 296
 Brachial plexus, neurotomy of, 328
 rupture of, 99
 Brailey, stretching supra-trochlear nerve, 413

 Brissaud, on neuroma, 494
 Brown-Séquard, on nerve-stretching, 346
 Bruns, case of multiple neuromata, 501
 Bulbs on nerves, 20
 Busch, on degeneration of nerves, 17
 Butlin, on nerve degeneration, 26
 on retained sensation after nerve section, 68
 Buzzard, on acute neuritis, 450
 nerve-stretching for epileptiform neuralgia, 422
 rheumatic neuritis, 463
 syphilitic neuritis, 461

 CADGE, neurotomy for facial neuralgia, 409
 Carl and Rattone, on tetanus, 313
 Carotid, ligature of, for neuralgia, 435
 Caspari, multiple neuritis, 480
 Causalgia, 271
 Cavañy, nerve-stretching for tabes, 363
 Céna's, on reflex paralysis, 295
 Cervical exostosis compressing nerves, 237
 Cervical plexus, neurotomy of, 328
 Charcot, on trophic lesions, 60
 on myelitis after nerve injury, 287
 case of spreading neuritis, 283
 Chavasse, excision of Meckel's ganglion, 432
 injury of sympathetic, 110
 Chorea, 302
 Complicated wounds of nerves, 161
 Complications of nerve injuries, 270
 Conductivity of nerves, 8
 Congestion of nerves, 270
 Contusion of nerves, 211
 cases of, 213
 Cornil and Ranvier on acute neuritis, 275
 Cossy and Dejeune, on degeneration of nerves, 18
 Crutch paralysis, 233
 Cysts of nerves, 492
 Czerny, nerve-stretching for epilepsy, 379
 nerve-stretching for myelitis, 369
 nerve-stretching for traumatic neuralgia, 399

- DAVIDSON, nerve-stretching for tabes, 367
 Debove, nerve-stretching for tabes, 366
 Degeneration of nerves, 16
 Délens, nerve injury complicating fracture, 251
 Dennis, excision of Meckel's ganglion, 431
 Desault, rupture of brachial plexus, 102
 Development of nerves, 1
 Diabetic gangrene, 456
 neuritis, 456
 Dislocations, nerve injury complicating, 263
 Doutréleont, nerve-stretching for myelitis, 369
 Dreschfeld, changes in spinal cord after amputation, 27
 Dubujadoux, true neuroma, 486
 Duhring, true neuroma, 487
 Duplay, fracture complicated by nerve injury, 261
 true neuroma, 487
 ECZEMA after nerve section, 43
 Edmunds, on changes in nerves after amputations, 28
 Efferent nerves, 5
 Electrical reactions after nerve section, 74
 Eichorst, multiple neuritis, 470
 End bulbs, 4
 Epilepsy, 302
 nerve-stretching for, 376
 Epileptiform neuralgia, 394
 excision of Meckel's ganglion for, 428
 treatment of, 419
 Erb, on contusion of nerves, 211
 on electrical reactions, 75
 Erichsen, fracture of humerus and injury of nerves, 249
 Esmarch, nerve-stretching for tabes, 365
 Estlander, nerve-stretching for traumatic neuralgia, 400
 Eulenberg, nerve-stretching for facial spasm, 382
 Exostosis compressing brachial plexus, 237
 Extensibility of nerves, 333
 FACIAL NERVE, injuries of, 116
 neurotomy of, 328
 Facial neuralgia, treatment of, 405
 Failure of primary suture, 160
 secondary suture, 207
 Fayrer, case of nerve contusion, 224
 Fenger, death from nerve-stretching, 353
 Fenger and Lee, on nerve-stretching, 347
 Fibromata of nerves, 493
 Flaubert, rupture of brachial plexus, 101
 Fracture of clavicle with nerve injury, 248
 femur, 258
 forearm, 255
 leg, 259
 humerus, 249
 scapula, 249
 Fractures, nerve injuries complicating, 243
 Friedrich, on changes in the spinal cord after amputation, 27
 GANGRENE after nerve section, 45
 Generisch, case of multiple neuroma, 499
 Genzman, changes in spinal cord after amputation, 27
 Gliomata of nerves, 491
 Gilbert, changes in nerves after amputation, 28
 Gillette, on nerve-stretching, 335
 nerve stretching for epilepsy, 379
 for tabes, 364
 Glossy skin, 41
 Glück, on union of nerves, 30
 Godlee, nerve-stretching for facial spasm, 383
 Grafting of nerves, 208
 Grant, neurotomy for facial neuralgia, 407
 Gray, nerve-stretching for facial spasm, 385
 Gross, ligature of carotid for facial neuralgia, 436
 Gums, condition of, in facial neuralgia, 414
 Gussenbauer, death from nerve-stretching, 353, 356
 HADDEN, alcoholic paralysis, 468
 Hair, trophic changes in, 47
 Hamilton, case of causalgia, 273
 injuries of superficial nerves, 120
 Hammond, nerve-stretching for athetosis, 375
 Hansen, neurectomy for wryneck, 389
 Harless and Haber, on stretching the spinal cord, 337
 Hayem, changes in spinal cord caused by nerve-stretching, 341
 on bulbs, 20
 on nerves after amputation, 28
 Herpes after nerve section, 43
 Hierschfelder, death from nerve-stretching, 353
 Hjelt, on nerve regeneration, 22
 Hilton, on trophic lesions, 41
 Hoffmann, nerve-stretching for facial spasm, 383
 Holden, cases of nerve suture, 146, 171
 Horsley, on nervi nervorum, 5
 Hulke, nerve injuries complicating fractures, 243
 Hutchinson, rupture of brachial plexus, 99
 ligature of carotid for neuralgia, 438
 Hypoglossal nerve, injuries of, 108
 IDIOPATHIC neuritis, 470
 Inferior dental nerve, neurotomy of, 323
 Inflammation of nerves, 270
 Infra-orbital nerve, neurotomy of, 323

- Injuries of special nerves, 84
 Intercoastal neuralgia, 418
 Israel, nerve injuries complicating fractures, 252
- JEFFROY, multiple neuritis, 479
 Johnson, nerve-stretching for tabes, 363, 364
 Joints, changes in after nerve section, 52
- KAUFMANN, nerve-stretching for facial spasm, 385
 nerve grafting, 208
 Keen, nerve-stretching for facial spasm, 386
 Korybutt-Daszkievicz, on degeneration of nerves, 23
 Kulenkampf, death from nerve-stretching, 353
 Kuster, nerve-stretching for traumatic neuralgia, 401
- LAMARKE, death from nerve-stretching, 354
 Lande, nerve-stretching for epilepsy, 378
 Lange, nerve injury complicating fracture, 253
 nerve-stretching for wryneck, 389
 Langer, nerve-stretching for tabes, 365
 Langenbuch, nerve-stretching for tabes, 366
 Langstaff, case of chronic neuritis, 282
 Langton, cases of nerve suture, 137, 141, 142, 144, 174, 176, 179, 180, 181, 182, 190, 195
 nerve-stretching for spastic spinal paralysis, 370
 Lanois, spontaneous paralysis of the arm, 449
 paralysis from cold, 453
 Latteaux, on nerve-stretching, 339
 Laurie, nerve-stretching for leprosy, 390
 Lauth, contusion of cervical nerves, 220
 Le Bret, rupture of the brachial plexus, 101
 Le Dentu, nerve-stretching for epilepsy, 427
 nerve injury complicating dislocation, 267
 Leegard, on nerve degeneration, 18
 on nerve regeneration, 24
 Lefferts, wound of recurrent laryngeal, 116
 Leflaire, rupture of the brachial plexus, 105
 Lent, on regeneration of nerves, 22
 Lepine, on reflex paralysis, 290
 Leprosy, condition of nerves in, 460
 nerve-stretching for, 390
 Létiévant, on retained sensation after nerve section, 64
 Leyden, on multiple neuritis, 481
 on reflex paralysis, 297
 on changes in the spinal cord after amputations, 27
- Liebrecht, injury of recurrent laryngeal, 116
 Lingual nerve, neurotomy of, 326
 Longuet, nerve-stretching for epileptiform neuralgia, 426
 Löwe, on development of nerves, 2
- MAAG, nerve-stretching for traumatic neuralgia, 400
 Malecot, on reflex paralysis, 291
 McCulloch, nerve-stretching for sclerosis of the cord, 373
 Marcus, on nerve-stretching, 340
 Marsh, cases of nerve suture, 166, 172
 Marshall, nerve-stretching for tabes, 364
 on nerve-stretching, 349
 Meckel's ganglion, excision of, 326
 excision of, for neuralgia, 428
 Median nerve, neurotomy of, 329
 symptoms of division of, 90
 Meissner's corpuscles, 5
 Mental nerve, neurotomy of, 325
 Menzies, union of nerve by first intention, 34, 130
 Mitchell, neurectomy for facial neuralgia, 408
 on acute neuritis, 276
 on nerve degeneration, 17
 on glossy skin, 42
 on joints after nerve section, 52
 on neuritis, 271
 on reflex paralysis, 289, 299
 on trophic changes in nails, 45
 mixed nerves, 8
- Monod, nerve-stretching for facial neuralgia, 412
 Morton, nerve-stretching for athetosis, 37
 for epilepsy, 378
 for neuralgia, 422
 for myelitis, 369
 for paralysis agitans, 373
 for spastic spinal paralysis, 371
 neurectomy for facial neuralgia, 411
 neuritis complicating dislocation, 266
- Morton and Cox, nerve-stretching for traumatic neuralgia, 400
 Motor nerves, 5
 Multiple neuritis, 467
 neuromata, 496
 Muscles, degeneration of, after nerve section, 51
 Muscles, contraction of, after nerve section, 73
 Muscular sense, 15
 tone, 9
 Musculo-cutaneous nerve, neurotomy of, 331
 Musculo-spiral nerve, injured by fracture, 250
 neurotomy of, 329
 symptoms of division of, 96
 Mussey, excision of Meckel's ganglion, 432

- Myelitis treated by nerve-stretching, 369
 Myxoma of ulnar nerve, 491
- NAILS, trophic changes in, 45
- Natural nerve current, 9
- Neck, injuries of nerves of, 108
- Nélaton, case of multiple neuromata, 497
- Nerve, changes in, after section, 16
 congestion of, 270
 contusion of, 211
 grafting, 208
 inflammation of, 270
 scar pressure on, 238
 stimuli, 11
 stretching, *see* Stretching
- Neumann, on regeneration, 22
- Neurectomy, 322
- Neuritis, acute, 450
 alcoholic, 467
 chronic, 279
 diabetic, 456
 from cold, 452
 gouty, 464
 multiple, 467
 idiopathic, 470
 in Raynaud's disease, 458
 rheumatic, 463
 symptoms of acute, 278
 syphilitic, 460
 traumatic, 274
 treatment of, 287, 484
- Neuralgia, causes of, 392
 epileptiform, 394
 intercostal, 418
 of extremities, 414
 of stumps, 401
 symptoms of, 393
 surgical treatment of, 392
 treatment of traumatic, 395
- Neuroma, 486
 multiple, 496
 plexiform, 495
 treatment of, 494
 true, 486
- Neurotomy, 322
- Neve, on nerve-stretching for leprosy, 390
- Nicaise, neurectomy for facial neuralgia, 411
 on electrical reactions, 75
- Nicolaer, on tetanus, 313
- Nussbaum, nerve-stretching for epilepsy, 379
 first case of nerve-stretching, 357
 ligature of carotid for epilepsy, 438
- OGLE, injury of sympathetic, 110
- Ollier, callus pressure on nerves, 250
- Omboni, nerve-stretching for traumatic neuralgia, 400
- Orbital nerves, injuries of, 117
- Ormerod, on syphilitic neuritis, 460
- Osteotomy followed by paralysis, 258
- PACINIAN corpuscles, 4
- Paget, on glossy skin, 41
 on contusion of nerves, 221
 rupture of the brachial plexus, 99
- Pain of nerve section, 62
 treatment of, 308
- Panas, nerve injury complicating fracture, 254
 cases of pressure on nerves, 235
 nerve-stretching for epilepsy, 377
 paralysis from cold, 453
- Paralysis agitans, nerve-stretching for, 372
- Paralysis after nerve section, 62
 of brachial plexus, 448
 of extensors of hand, 444
 of muscles of hand, 444
 reflex, 289
 spontaneous, of arm, 449
- Partial division of nerves, 80
- Parturition, pressure on nerves during, 238
- Paulet, nerve-stretching for traumatic neuralgia, 400
- Payne, injury of sympathetic, 110
- Pemphigus, 43
- Perforating ulcer, nerve changes in, 454
- Petersen, nerve-stretching for traumatic neuralgia, 400
- Physiology of the nerves, 8
- Pierson, on multiple neuritis, 481
- Plexiform neuroma, 495
- Pneumogastric nerve, injuries of, 113
- Podrazki, excision of Meckel's ganglion, 432
- Polailon, nerve-stretching for epileptiform neuralgia, 421, 425, 427
- Poore, on trophic lesions, 58
- Pozzi, neuritis complicating dislocation, 266
- Pressure on nerves, 231
 treatment of, 239
- Prévost, on nerve-stretching, 346
- Primary suture of nerves, 126
 prognosis of, 158
- Prognosis of secondary suture, 203
- Prudden, on multiple neuromata, 497
- Punctured wound of nerves, 80
- Purdie, nerve-stretching for traumatic neuralgia, 401
- Putnam, nerve-stretching for facial spasm, 382, 384
- QUINQUAUD, on nerve-stretching, 339, 344, 345
- RADIAL nerve, symptoms of division of, 96
- Rake, on nerve-stretching for leprosy, 391
- Raynaud's disease, neuritis in, 458
- Reaction of degeneration, 75
- Recurrent laryngeal nerve, injuries of, 115
- Reflex paralysis, 289
- Regeneration of nerves, 21
- Reynolds, on the condition of nerves after amputation, 28

- Rheumatic neuritis, 463
 Richelot, on changes in temperature after nerve section, 50
 Richet, on retained sensation after nerve section, 65
 Rivington, injury of the pneumogastric, 113
 Robson, reflex paralysis, 297
 nerve grafting, 209
 Rokitsansky, on acute neuritis, 275
 Rosenstein, death after nerve-stretching, 354
 Ross, rupture of the brachial plexus, 104
 Roth, multiple neuritis, 477
 Rupture of brachial plexus, 99
 Rumpf, death from nerve-stretching, 354
- SABATIER, injuries of the sympathetic, 120
 Sands, neurotomy for wryneck, 388
 Sands and Seguin, case of chronic neuritis, 281
 Sarcoma of nerves, 491
 Satterthwaite, case of multiple neuromata, 503
 Savory, cases of nerve contusion, 219
 cases of nerve suture, 138, 139, 140, 192, 193
 on retained sensation after nerve section, 68
 injury of the pneumogastric, 113
 Scar pressure on nerves, 238
 Scheving, on nerve-stretching, 339
 Schüssler, nerve-stretching for facial spasm, 382
 Sciatic nerve, symptoms of division of, 107
 neurotomy of, 329
 Sciatica, treatment of, 418
 Secondary suture, 164
 cases of, 166
 failure of, 207
 prognosis of, 203
 statistics of, 197
 value of, 197
 Sée, nerve-stretching for facial spasm, 411
 Sensation, loss of, after nerve section, 63
 Sense of pain, 14
 temperature, 13
 Sensibilité supplée, 71
 Sensory nerves, 4
 Sheill, nerve injury complicating dislocation, 269
 Shock after nerve section, 62
 Sibley, case of multiple neuromata, 49
 Simultaneous injury of several nerves, 97
 Skin eruptions after nerve injury, 43
 trophic changes in, 41
 Smith, contusion of nerves of arm, 217
 case of scar pressure, 241
 cases of nerve suture, 130, 131, 133, 149, 166
 nerve injury complicating fracture, 244
 Smith, nerve-stretching for traumatic neuralgia, 397
 Spastic spinal paralysis, nerve-stretching for, 370
 Spence, nerve-stretching for traumatic neuralgia, 401
 Spinal accessory nerve, neurotomy of, 327
 cord, changes in, after amputation, 27
 changes in, caused by nerve-stretching, 341
 disease of, after neuritis, 86
 effect of nerve-stretching on, 337
 Southam, nerve-stretching for facial spasm, 383
 Statistics of primary suture, 153
 Stewart, on multiple neuritis, 470
 nerve-stretching for epileptiform neuralgia, 420
 Stintzing, on the strength of nerves, 336
 on nerve-stretching, 344
 Strauss, paralysis of the brachial plexus, 448
 Strength of nerves, 333
 Stretching of nerves, 339
 anatomical changes caused by, 339
 bloodless, 351
 clinical application of, 357
 dangers of, 351
 mode of action of, 347
 operation of, 350
 physiological effects of, 343
 for athetosis, 374
 for disease of the brain, 368
 for epilepsy, 376
 for epileptiform neuralgia, 419
 for intercostal neuralgia, 418
 for facial spasm, 380
 for leprosy, 390
 for local spasm, 380
 for myelitis, 369
 for neuralgia of extremities, 414
 for paralysis agitans, 372
 for sclerosis of the cord, 373
 for spastic spinal paralysis, 371
 for tabes dorsalis, 359
 for tetanus, 359
 for wryneck, 286
 Structure of nerves, 2
 Stumps, neuralgia of, 401
 Subcuticular whitlow, 43
 Superficial nerves, wounds of, 47
 Supra-orbital nerve, neurotomy of, 322
 Supra-trochlear nerve, neurotomy of, 322
 Suture of nerves, 124
 cases of primary, 129
 failure of primary, 160
 material for, 128
 primary, 126
 prognosis of primary, 158
 secondary, 164
 value of secondary, 152
 Swan, injuries of superficial nerves, 118

- Sweat, secretion of, after nerve section, 48
 Symington, on nerve-stretching, 334
 Symonds, case of rupture of brachial plexus, 105
 Sympathetic system, 6
 nerve, injuries of, 107
 Symptoms of nerve injuries, 62
 Syphilitic neuritis, 460
 Szuman, nerve injury complicating fracture, 258
- TABES dorsalis, nerve-stretching for, 359
 Tactile sensation, 13
 Tarnowski, on nerve-stretching, 340
 changes in spinal cord caused by nerve-stretching, 342
 Teeth, condition of, in facial neuralgia, 441
 Temperature after nerve section, 48
 Tetanus, 304
 bacillus of, 313
 neurotomy for, 307
 nerve-stretching for, 375
 Thiersch, nerve-stretching for spastic spinal paralysis, 371
 Tibial nerves, neurotomy of, 330
 Tic, facial, nerve-stretching for, 380
 Tillanx, experiment on nerve-stretching, 334
 neurectomy for wryneck, 389
 on contusion of nerves, 211
 nerve injury complicating fracture, 252
 Tillemans, on nerve grafting, 208
 Torticollis, operations on nerves for, 386
 Treatment of nerve section, 123
 of neuritis, 484
 of pressure on nerves, 239
 Trélat, nerve injury complicating fracture, 253
 Trophic lesions, 41
 nerves, 57
 Trousseau, on epileptiform neuralgia, 394
 Tumours, compression of nerves by, 236
 Tutschek, on nerve-stretching, 343
- ULCERS, occurrence of, after nerve section, 44
 Ulnar nerve, deformity after section of, 85
 symptoms of division of, 84
 neurotomy of, 329
 Union after excision of nerve, 38
 by first intention, 30
- Union of nerves, 21
- VANDERVEER, excision of Meckel's ganglion, 431
 Valentin, on nerve-stretching, 339, 343
 Varieties of nerve injuries, 211
 Vieusse, reflex paralysis, 298
 Visceral nerves, 6
 Vogt, on nerve-stretching, 333, 339
 nerve-stretching for traumatic neuralgia, 399
 Vulpian, on crutch paralysis, 233
 on muscles after nerve section, 57
 on changes in the spinal cord after amputation, 27
 case of chronic neuritis, 285
- WALES, nerve-stretching for traumatic neuralgia, 399
 Wallace, nerve-stretching for leprosy, 390
 Wallerian degeneration, 16
 Walsham, cases of nerve suture, 168, 191
 nerve-stretching for epileptiform neuralgia, 424
 Webber, multiple neuritis, 478
 Weltrubski, death from nerve-stretching, 354
 Westphal, death from nerve-stretching, 355
 nerve-stretching for spastic spinal paralysis, 372
 for paralysis agitans, 372
 White, on the changes in nerves after amputation, 23
 Whitehead, nerve-stretching for epileptiform neuralgia, 422
 Whitson, nerve injury complicating fracture, 257
 Wiet, on nerve-stretching, 340, 344
 Willett, cases of nerve contusion, 215, 218
 cases of nerve suture, 135, 137, 145, 173, 183, 184, 185, 186, 189
 nerve injury complicating fracture, 245, 247
 Wood, excision of Meckel's ganglion, 434
- ZESAS, nerve-stretching for facial spasm, 385

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INDEX.

- Abercrombie's Medical Jurisprudence, 4
 Adams (W.) on Clubfoot, 11
 — on Curvature of the Spine, 11
 Allingham (H.) on Derangements of Knee-joint, 11
 Allingham (W.) on Diseases of the Rectum, 14
 Barnes (R.) on Obstetric Operations, 5
 — on Diseases of Women, 5
 Basil's Commoner Diseases and Accidents, 10
 Bateman's Aphasia, 9
 Beale on Liver, 8
 — Microscope in Medicine, 8
 — Slight Ailments, 8
 — Urinary and Renal Derangements, 13
 Bellamy's Surgical Anatomy, 3
 Bentley and Trimen's Medicinal Plants, 7
 Bentley's Manual of Botany, 7
 — Structural Botany, 7
 — Systematic Botany, 7
 Berkart's Bronchial Asthma, 9
 Bernard on Stammering, 9
 Blair's Analysis of Potable Waters, 4
 Bowlby's Injuries and Diseases of Nerves, 11
 — Surgical Pathology and Morbid Anatomy, 11
 Braune's Topographical Anatomy, 3
 Brodhurst's Anchylosis, 11
 — Curvatures, &c., of the Spine, 11
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 Bryant's Acute Intestinal Strangulation, 10
 — Practice of Surgery, 11
 — Tension. Inflammation of Bone, Injuries, &c., 11
 Bucknill and Tuke's Psychological Medicine, 5
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 Bulkley's Diseases of the Skin, 13
 Burton's Midwifery for Midwives, 6
 Butlin's Malignant Disease of the Larynx, 13
 — Operative Surgery of Malignant Disease, 13
 — Sarcoma and Carcinoma, 13
 Buzzard's Diseases of the Nervous System, 9
 — Peripheral Neuritis, 9
 Byford's Diseases of, and Accidents to, Women, 6
 Carpenter's Human Physiology, 4
 Charteris on Health Resorts, 10
 — Practice of Medicine, 8
 Chevers' Diseases of India, 7
 Churchill's Face and Foot Deformities, 11
 Clouston's Lectures on Mental Diseases, 5
 Cooper's Syphilis and Pseudo-Syphilis, 14
 Courty's Diseases of the Uterus, Ovaries, &c., 5
 Cripps' Cancer of the Rectum, 14
 — Diseases of the Rectum and Anus, 14
 Cullingworth's Manual of Nursing, 6
 — Short Manual for Monthly Nurses, 6
 Dalby's Diseases and Injuries of the Ear, 12
 — Short Contributions, 12
 Day on Diseases of Children, 6
 — on Headaches, 10
 Dobell's Lectures on Winter Cough, 8
 — Loss of Weight, &c., 8
 Domville's Manual for Nurses, 6
 Doran's Gynæcological Operations, 6
 Down's Mental Affections of Childhood, 5
 Druiitt's Surgeon's Vade-Mecum, 11
 Duncan (A.) on Prevention of Disease in Tropics, 7
 Duncan (J. M.), on Diseases of Women, 5
 Ebstein on Regimen in Gout, 9
 Ellis's (E.) Diseases of Children, 6
 Ellis's (T.S.) Human Foot, 11
 Ewart's Bronchi and Pulmonary Blood Vessels, 8
 Fagge's Principles and Practice of Medicine, 8
 Fayrer's Climate and Fevers of India, 7
 — Natural History, etc., of Cholera, 7
 Fenwick (E. H.), Electric Illumination of Bladder, 14
 Fenwick's (S.) Medical Diagnosis, 8
 — Obscure Diseases of the Abdomen, 8
 — Outlines of Medical Treatment, 8
 — The Saliva as a Test, 8
 Flint's Principles and Practice of Medicine, 7
 Flower's Diagrams of the Nerves, 3
 Fowler's Dictionary of Practical Medicine, 8
 Fox's (C. B.) Examinations of Water, Air, and Food, 4
 Fox's (T.) Atlas of Skin Diseases, 13
 Fox (Wilson), Atlas of Pathological Anatomy of Lungs, 8
 Fraser's Operations on the Brain, 11
 Freyer's Litholopaxy, 14
 Galabin's Diseases of Women, 6
 Galabin's Manual of Midwifery, 5
 Godlee's Atlas of Human Anatomy, 3
 Goodhart's Diseases of Children, 6
 Gorgas's Dental Medicine, 12
 Gowers' Diseases of the Brain, 9
 — Diseases of the Spinal Cord, 9
 — Manual of Diseases of Nervous System, 9
 — Medical Ophthalmoscopy, 9
 Granville on Gout, 9
 Guy's Hospital Formulæ, 2
 — Reports, 2
 Habershon's Diseases of the Abdomen, 10
 Harley on Diseases of the Liver, 9
 — Inflammations of the Liver, 9
 Harris's (C. A.) Dentistry, 13
 Harris's (V. D.) Diseases of Chest, 8
 Harrison's Surgical Disorders of the Urinary Organs, 12
 Hartridge's Refraction of the Eye, 12
 Harvey's Manuscript Lectures, 3
 Heath's Certain Diseases of the Jaws, 10
 — Injuries and Diseases of the Jaws, 10
 — Minor Surgery and Bandaging, 10
 — Operative Surgery, 10
 — Practical Anatomy, 3
 — Surgical Diagnosis, 10
 Higgins' Ophthalmic Out-patient Practice, 12
 Hillis' Leprosy in British Guiana, 13
 Hirschfeld's Atlas of Central Nervous System, 4
 Holden's Dissections, 3
 — Human Osteology, 3
 — Landmarks, 3
 Hood's (D. C.) Diseases and their Commencement, 6
 Hood (P.) on Gout, Rheumatism, &c., 9
 Hooper's Physician's Vade-Mecum, 7
 Hutchinson's Clinical Surgery, 11
 — Rare Diseases of the Skin, 13
 Hyde's Diseases of the Skin, 13
 Jacobson's Operations of Surgery, 11
 James (P.) on Sore Throat, 12
 Jessett's Cancer of the Mouth, &c., 13
 Johnson's Asphyxia, 8
 — Medical Lectures and Essays, 8
 Jones (C. H.) and Sieveking's Pathological Anatomy, 4
 Jones' (H. McN.) Diseases of the Ear and Pharynx, 12
 — Atlas of Diseases of Membrana Tympani, 12
 Journal of Mental Science, 2
 Keyes' Genito-Urinary Organs and Syphilis, 13
 Lancereaux's Atlas of Pathological Anatomy, 4
 Lane and Griffiths' Rheumatic Diseases, 9
 Lawson's Milroy Lectures on Epidemiology, 5
 Lewis (Bevan) on the Human Brain, 4
 Liebreich's Atlas of Ophthalmoscopy, 12
 London Hospital Pharmacopœia, 2
 Lückes' Hospital Sisters and their Duties, 6
 Macdonald's (J. D.) Examination of Water and Air, 4
 Mackenzie on Diphtheria, 12
 MacLagan on Fever, 8
 McLeod's Operative Surgery, 10
 MacMunn's Clinical Chemistry of Urine, 13
 Macnamara's Diseases of the Eye, 12
 — Bones and Joints, 11
 Mapother's Papers on Dermatology, 13
 Martin's Ambulance Lectures, 10
 Maxwell's Terminologia Medica Polyglotta, 14
 Mayne's Medical Vocabulary, 14
 Middlesex Hospital Reports, 2
 Moore's (N.) Pathological Anatomy of Diseases, 4
 Moore's (Sir W. J.) Family Medicine for India, 7
 — Manual of the Diseases of India, 7
 — Constitutional Requirements of Tropical Climates, 7
 Morris' (H.) Anatomy of the Joints, 3
 Morton's Spina Bifida, 11
 Mouat and Snell on Hospitals, 4
 Nettleship's Diseases of the Eye, 12
 Nixon's Hospital Practice, 8
 Ogle on Puncturing the Abdomen, 10
 Ogston's Medical Jurisprudence, 4
 Ophthalmic (Royal London) Hospital Reports, 2
 Ophthalmological Society's Transactions, 2
 Oppert's Hospitals, Infirmarys, Dispensaries, &c., 4
 Owen's Materia Medica, 6
 Parkes' Practical Hygiene, 5
 Pavy on Diabetes, 10
 Pharmaceutical Journal, 2
 Pollock's Histology of the Eye and Eyelids, 12
 — Leprosy as a Cause of Blindness, 12
 Priestley's Intra-Uterine Death, 5

[Continued on the next page.]

- Purcell on Cancer, 13
 Rae's Eczema and its Treatment, 13
 Raye's Ambulance Handbook, 10
 Rentoul's Dignity of Woman's Health, 8
 Reynolds' (J. J.) Diseases of Women, 5
 Notes on Midwifery, 5
 Richardson's Mechanical Dentistry, 12
 Roberts' (D. Lloyd) Practice of Midwifery, 5
 Robinson's (Tom) Eczema, 14
 Illustrations of Skin Diseases, 14
 Syphilis, 14
 Robinson (W.) Endemic Gout or Thyreoele, 12
 Ross's Aphasia, 9
 Diseases of the Nervous System, 9
 Routh's Infant Feeding, 6
 Royal College of Surgeons Museum Catalogues, 2
 Royle and Harley's Materia Medica, 7
 St. Bartholomew's Hospital Catalogue, 2
 St. George's Hospital Reports, 2
 St. Thomas's Hospital Reports, 2
 Sansom's Valvular Disease of the Heart, 9
 Shore's Elementary Practical Biology, 4
 Sieveking's Life Assurance, 14
 Silk's Manual of Nitrous Oxide, 12
 Simon's Public Health Reports, 5
 Smith's (E.) Clinical Studies, 6
 Diseases in Children, 6
 Wasting Diseases of Infants and Children, 6
 Smith's (J. Greig) Abdominal Surgery, 6
 Smith's (Henry) Surgery of the Rectum, 14
 Snow's Palliative Treatment of Cancer, 13
 Reappearance of Cancer, 13
 Southam's Regional Surgery, 11
 Squire's (P.) Companion to the Pharmacopœia, 7
 Pharmacopœias of London Hospitals, 7
 Squire's (W.) Essays on Preventive Medicine, 7
 Stevenson's Electricity in Disease, 11
 Uses of Electrolysis, 11
 Stocken's Dental Materia Medica and Therapeutics, 13
 Sutton's General Pathology, 4
 Swain's Surgical Emergencies, 10
 Swayne's Obstetric Aphorisms, 6
 Taylor's (A. S.) Medical Jurisprudence, 4
 Taylor's (F.) Practice of Medicine, 8
 Thin's Cancerous Affections of the Skin, 13
 Pathology and Treatment of Ringworm, 1
 Thomas's Diseases of Women, 6
 Thompson's (Sir H.) Calculous Disease, 14
 Diseases of the Prostate, 14
 Diseases of the Urinary Organs, 14
 Lithotomy and Lithotripsy, 14
 Stricture of the Urethra, 14
 Suprapubic Operation, 14
 Surgery of the Urinary Organs, 14
 Tumours of the Bladder, 14
 Thorowgood on Asthma, 9
 on Materia Medica and Therapeutics, 6
 Tibbits' Map of Motor Points, 10
 How to use a Galvanic Battery, 10
 Electrical and Anatomical Demonstrations, 10
 Tilt's Change of Life, 6
 Uterine Therapeutics, 6
 Tirard's Prescriber's Pharmacopœia, 7
 Tomes' (C. S.) Dental Anatomy, 12
 Tomes' (J. and C. S.) Dental Surgery, 12
 Tooth's Spinal Cord, 9
 Treves and Lang's German-English Dictionary, 14
 Tuke's Influence of the Mind upon the Body, 5
 Sleep-Walking and Hypnotism, 5
 Unofficial Formulary, 2
 Vintras on the Mineral Waters, &c., of France, 10
 Walsham's Surgery: its Theory and Practice, 10
 Waring's Indian Bazaar Medicines, 7
 Practical Therapeutics, 7
 Warner's Guide to Medical Case-Taking, 8
 Waters' (A. T. H.) Contributions to Medicine, 7
 West (C.) and Duncan's Diseases of Women, 5
 West's (S.) How to Examine the Chest, 8
 Wilks' Diseases of the Nervous System, 8
 Wilson's (Sir E.) Anatomists' Vade-Mecum, 3
 Wilson's (G.) Handbook of Hygiene, 5
 Healthy Life and Dwellings, 5
 Wolfe's Diseases and Injuries of the Eye, 12
 Wolfenden and Martin's Pathological Anatomy, 12
 Wynter and Wethered's Practical Pathology, 4
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450
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